LTECC C1-2722/32 #2

# 2550
# DATA AMPLIFIER

# 160
# ENCLOSURE

DANA™

Dana Laboratories Incorporated
Irvine, California 92664

Telephone (714) 833-1234
Teletype 910-595-1136

980393

# 2550
# DATA AMPLIFIER

# 160
# ENCLOSURE

DANA™

Dana Laboratories Incorporated
Irvine, California 92664

Telephone (714) 833-1234
Teletype 910-595-1136

January, 1970

Digitized by the Internet Archive
in 2025

https://archive.org/details/manualsplus_07300

TABLE OF CONTENTS


| SECTION | TITLE | PAGE |
|---|---|---|
| 1 | INTRODUCTION | 1-1 |
| 1.1 | Introduction | 1-1 |
| 1.2 | Operational Description | 1-1 |
| 1.3 | Gain Option | 1-1 |
| 1.4 | Specifications | 1-3 |
| 1.5 | Dana Model 160 Amplifier Enclosure | 1-7 |
| 2 | INSTALLATION | 2-1 |
| 2.1 | Unpacking and Inspection | 2-1 |
| 2.2 | Amplifier Power Requirements | 2-1 |
| 2.3 | Input-Output Connections | 2-1 |
| 2.3.1 | Enclosure Power | 2-2 |
| 2.3.1.1 | Power Consumption | 2-2 |
| 2.3.2 | Input-Output Signals | 2-2 |
| 2.4 | Initial Checkout Procedures | 2-4 |
| 2.4.1 | Initial 2195 Test Panel Setup for the 2550 Amplifier | 2-5 |
| 2.4.2 | RTO Zero Check | 2-7 |
| 2.4.3 | Gain Check | 2-7 |
| 2.4.4 | Variband | 2-8 |
| 2.4.5 | Common Mode Rejection | 2-8 |
| 2.4.6 | FET Switch Check | 2-9 |
| 2.5 | Signal Conditioning Sub System | 2-9 |
| 2.5.1 | General | 2-9 |
| 2.5.2 | Individual Channel Check | 2-9 |
| 2.5.3 | RTO Zero Channel Check | 2-10 |
| 2.5.4 | Full Scale Output Check | 2-11 |
| 2.5.5 | Enclosure Mounting | 2-11 |
| 2.5.5.1 | Rack Mounting | 2-11 |
| 2.5.5.2 | Hard Mounting | 2-11 |
| 3 | OPERATION | 3-1 |
| 3.1 | Modes of Operation | 3-1 |
| 3.2 | Controls | 3-1 |
| 3.2.1 | Balance on Zero Adjustment | 3-1 |
| 3.2.2 | Gain Vernier Adjustment | 3-4 |
| 3.2.3 | Other Adjustments | 3-4 |
| 3.3 | Use of Bifurcated Terminals | 3-4 |
| 3.4 | Operating Procedures | 3-5 |

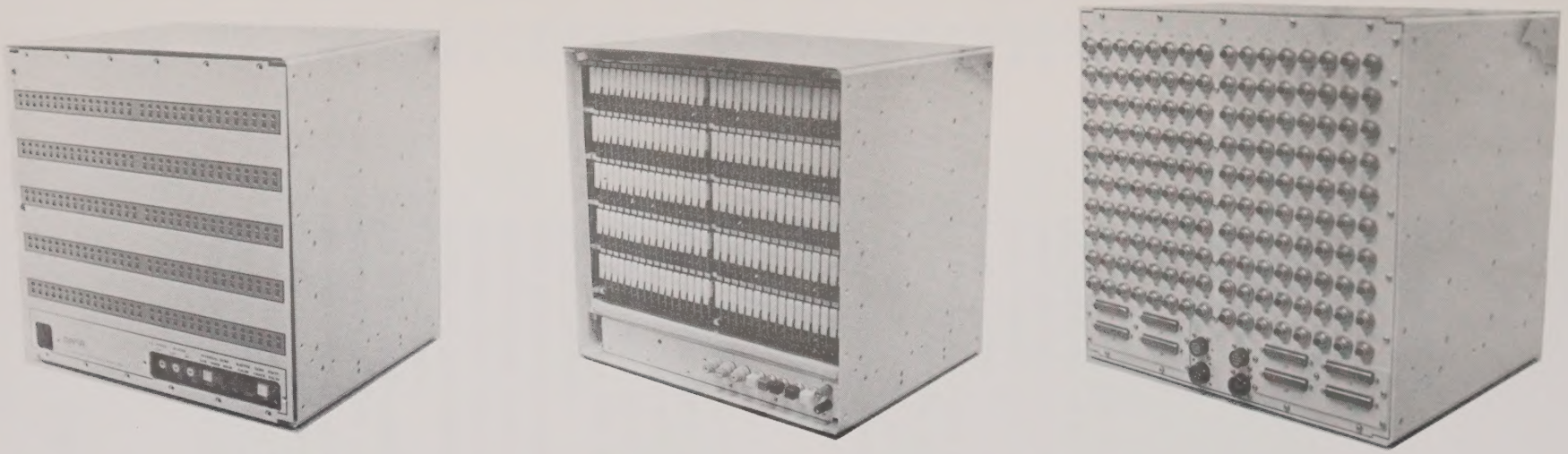
Table of Contents (Continued)


| | | |
|---|---|---|
| 4 | CIRCUIT DESCRIPTION | 4-1 |
| 4.1 | Introduction | 4-1 |
| 4.1.1 | Normal Mode Amplifier | 4-2 |
| 4.1.2 | Common Mode Amplifier | 4-4 |
| 4.2 | Input Amplifier | 4-7 |
| 4.2.1 | Feedback Circuit | 4-9 |
| 4.2.2 | Additional Circuit Details | 4-10 |
| 4.3 | Variband Filter | 4-13 |
| 4.4 | Output Amplifier | 4-14 |
| 4.5 | F.E.T. Switch | 4-15 |
| 4.6 | Model 160 Enclosure | 4-16 |
| 4.6.1 | Temperature Controller | 4-16 |
| 4.6.2 | Amplifier Power Supply | 4-17 |
| 5 | MAINTENANCE | 5-1 |
| 5.1 | Test Equipment | 5-1 |
| 5.2 | Lissajous Figures in Testing the 2550 Amplifier | 5-2 |
| 5.3 | Calibration Procedures | 5-3 |
| 5.3.1 | Common Mode Adjustment | 5-6 |
| 5.3.2 | Collector Zero Adjustment | 5-7 |
| 5.3.3 | Input Offset Current Adjustment | 5-8 |
| 5.3.4 | Output Zero Adjustment | 5-8 |
| 5.4 | Tests of Amplifier Characteristics | 5-9 |
| 5.4.1 | AC Gain Measurement | 5-9 |
| 5.4.2 | Linearity Measurements | 5-11 |
| 5.4.3 | Bandwidth Measurement | 5-11 |
| 5.4.4 | Variband Measurement | 5-12 |
| 5.4.5 | Output Limiting | 5-12 |
| 5.4.6 | F.E.T Calibration Circuit | 5-13 |
| 5.5 | Enclosure Temperature Controller Calibration | 5-14 |
| 5.5.1 | Bottom Enclosure Panel Disassembly | 5-14 |
| 5.5.2 | Calibration of Temperature Controller | 5-14 |
| 6 | DRAWINGS | 6-1 |
| 7 | PARTS LIST | 7-1 |
| 8 | APPENDIX A | 8-1 |

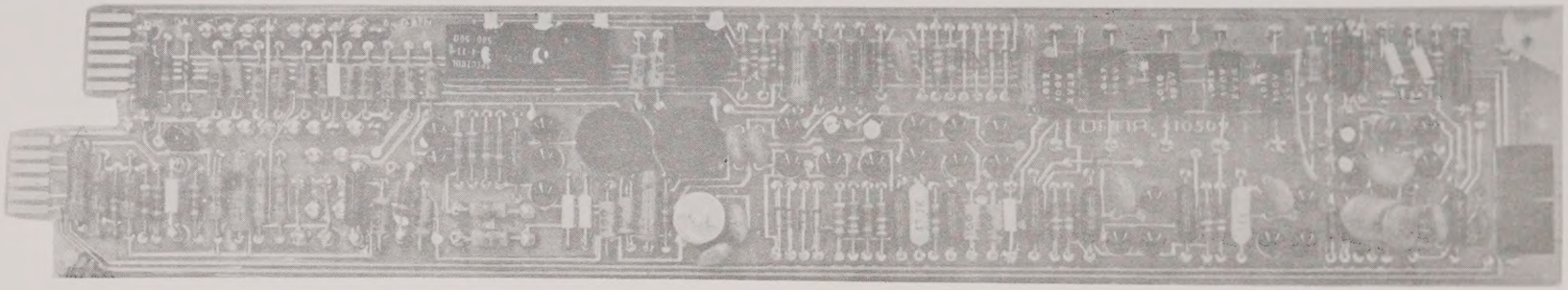
# LIST OF ILLUSTRATIONS


| Figure | Title | Page |
|---|---|---|
| 1.a | Signal Conditioning Subsystems | |
| 1.b | Block Diagram Model 2550 | 1-2 |
| 1.c | Input Attenuator Circuit | 1-3 |
| 1.d | Model 160 Enclosure - Rear Panel | 1-6 |
| 1.e | Temperature Controller/Power Supply | 1-8 |
| 2.a | Input and Output Connections | 2-3 |
| 2.b | PC Board Edge Identification | 2-3 |
| 2.c | Extender Card | 2-10 |
| 3.a | Modes of Operation | 3-1 |
| 3.b | Balance/Zero Potentiometer in Zero Configuration | 3-2 |
| 3.c | Balance/Zero Potentiometer in Balance Configuration | 3-2 |
| 3.d | 2550 Amplifier Bifurcated Terminals | 3-3 |
| 4.a | Block Diagram | 4-1 |
| 4.b | Normal Mode and Common Mode Response | 4-2 |
| 4.c | Simplified Potentiometric Amplifier | 4-2 |
| 4.d | Potentiometric Amplifiers in Differential Configuration | 4-3 |
| 4.e | Differential Stage for Summation of Inputs | 4-3 |
| 4.f | Normal Mode Amplifier and Common Mode Amplifier | 4-4 |
| 4.g | Voltage Dividers | 4-5 |
| 4.h | Gain Set | 4-6 |
| 4.i | Input Amplifier | 4-6 |
| 4.j | Equivalent Bridge | 4-7 |
| 4.k | Equivalent Feedback Network for Gain of 1000 | 4-9 |
| 4.l | Forced Internal Symmetry | 4-10 |
| 4.m | Filter Capacitor Values | 4-12 |
| 4.n | Active Admittance Filter | 4-13 |
| 4.o | Filter Cutoff | 4-13 |
| 4.p | Gain Vernier in CCW Position | 4-14 |
| 4.q | Gain Vernier in CW Position | 4-15 |
| 4.r | FET Calibration Circuit | 4-15 |
| 4.s | +6.500 VDC Supply | 4-18 |
| 5.a | Model 2195 Test Panel | 5-2 |
| 5.b | Common Mode Lissajous Figures | 5-2 |
| 5.c | 2195 Test Panel Set Up | 5-4 |
| 5.d | Common Mode Test with the 2195 Test Panel | 5-7 |
| 5.e | Block Diagram of Test Panel Set Up for Gain Test | 5-9 |
| 5.f | Bottom Panel Temperature Controller Adjustment | 5-15 |
| 5.g | Thermistor Conversion Table | 5-16 |

| Table | | |
|---|---|---|
| 1.1 | Specifications | 1-4 |



Dana Model 160 Enclosure



DC Amplifier Model 2550

Figure 1a - Signal Conditioning Subsystem

# SECTION 1

# GENERAL DESCRIPTION

## 1.1 INTRODUCTION

The Dana Model 2550 Data Amplifier (figure 1a) is a low-level D.C. instrumentation amplifier providing a wideband 2 kHz maximum output. The amplifier employs a five pole Butterworth Variband filter. The amplifier delivers ± 5.11 volts full scale output; full scale current output is 200 microamperes. The amplifier is designed to drive high impedance loads such as multiplexers, low power recorders, and display devices requiring less than 200 μA.

## 1.2 OPERATIONAL DESCRIPTION

All instrumentation amplifiers are confronted with the problem of common mode voltage—the voltage existing between each of a pair of input lines and common. This common mode voltage is amplified with the differential input voltage—the voltage across the two differential inputs. The result is inaccurate measurements of the differential input voltage. Dana amplifiers use a separate common mode amplifier to maintain this effect at a minimum.

Figure 1b is a block diagram of the 2550 amplifier. The normal mode amplifier is a differential amplifier that amplifies the differential input voltage. Common mode voltage is effectively cancelled out in the normal mode amplifier by the output of the common mode amplifier. The common mode amplifier does this by sensing the common mode component of the signal in the first stage of the normal mode amplifier and supplying an opposing voltage. The normal mode amplifier feedback is returned through the attenuator. The output of the amplifier also is fed to the variband filter. The output is applied to the output amplifier which is an operational amplifier with a gain of 1 to 2.5. The output amplifier will drive ± 5.11 volts into a load of 100 kohms.

The normal mode amplifier gain is set by a voltage divider in the feedback circuit. This is the attenuator section of the 2550 amplifier. Precision resistors are jumpered into this circuit with each gain factor.

## 1.3 GAIN OPTION

Two combinations of gains are available on the 2550. Gains of .16, .4, 1, 2, 4 and 10 are obtained in the X.01 ("times" .01) position. The X.01 gain position may be obtained by placing the jumpers TPA and

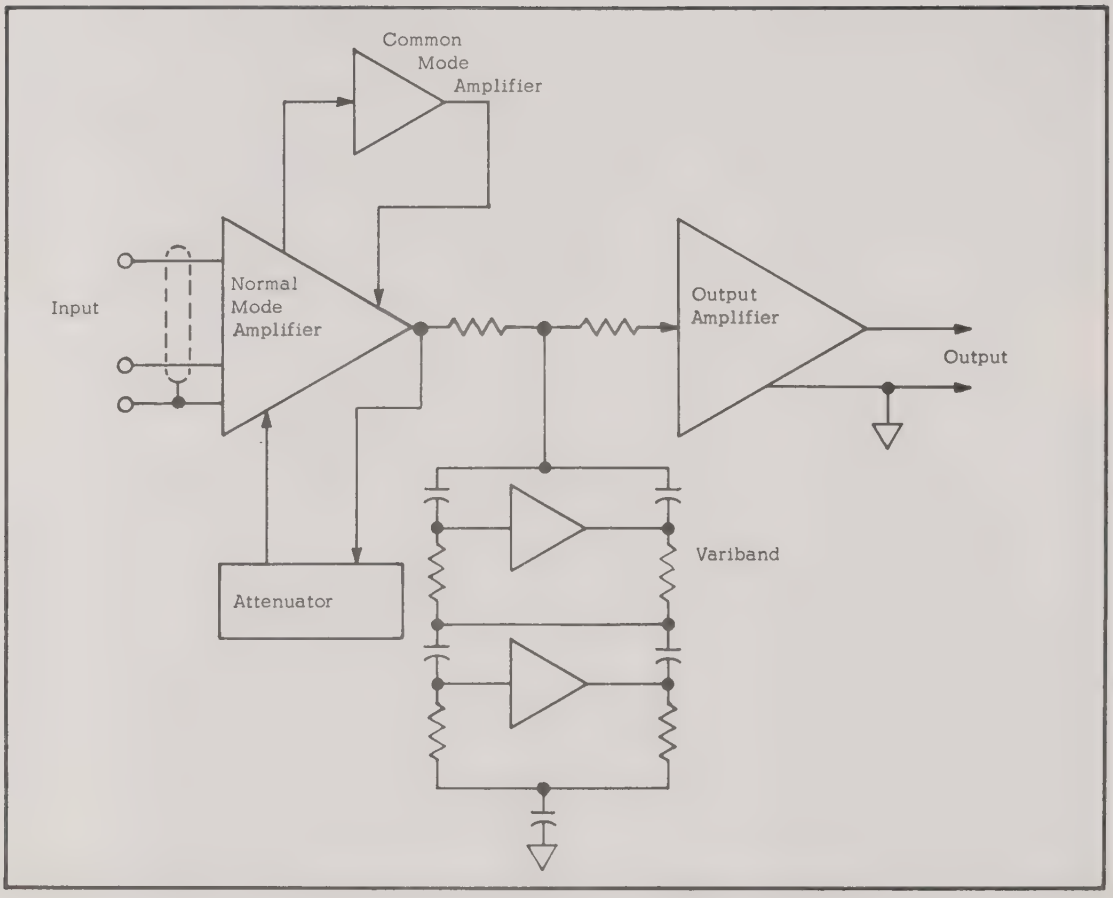



Figure 1.b - Block Diagram, Model 2550

TPB in positions 2. Gains of 16, 40, 100, 200, 400, and 1000 are obtained when the amplifier is in the X1 (times 1 position).

For the X1 gains, place the jumpers TPA and TPB in position 1. A vernier adjustment extends each range by a factor of 2.5 times the gain. This provides continuous selection of gains from .16 to 2500. The attenuator input circuitry can be seen in figure 1c. The X.01 position is a voltage divider with a 100 to 1 ratio. Equal amounts of the incoming signal will flow into both the plus and negative inputs.

## 1.4 SPECIFICATIONS

Specifications are listed in Table 1.1.

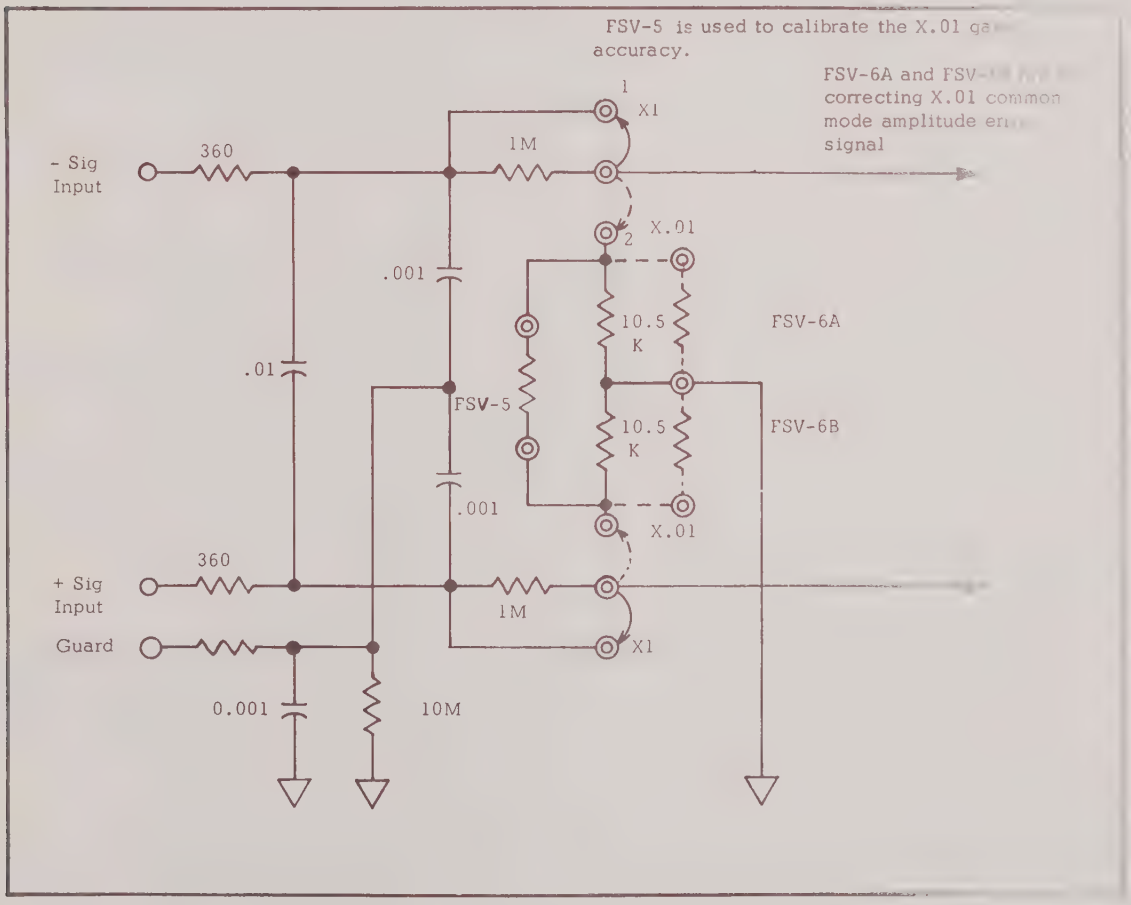



Figure 1.c - Input Attenuator Circuit

Table 1.1 - Specifications

All specifications apply with sources of up to 350 ohms, in any unbalance.

**GAIN**

| | |
|---|---|
| Steps | X1 16, 40, 100, 200, 400, 1000<br>X.01 .16, .4, 1, 2, 4, 10 |
| Vernier | Continuously variable up to 2.5 times the step gain. |
| Accuracy | ± 0.1% |
| Resolution | ± .25% (Gain Vernier potentiometer) |

**OUTPUT**

| | |
|---|---|
| Voltage | 5.11 VDC or peak AC to 2 kHz |
| Current | 200 µA |
| Resistance | Less than 100 ohm |
| Capacitive Load | .001 µf without instability |
| Short Circuit Current | Short circuit proof, output current limited to: + 2 mA; -400 µA |
| Voltage clamps | + 6V nominal; -10.5V nominal |

**COMMON MODE**

Rejection

| Source Unbalance | Gain | Common Mode Rejection |
|---|---|---|
| 100 ohm | 40-1000 | 60 dB + "K" in dB |
| 1000 ohm | 16, 40 | 60 dB + "K" in dB |
| 1000 ohm | 10 or less | 54 dB |

Voltage: ± 10 VDC or peak AC operating DC to 400 Hz.
± 30 VDC or peak AC no damage.

**WIDEBAND NOISE**

| | |
|---|---|
| RTO at k = 1000 | less than 4 mV RMS |
| RTO at k = 10 | less than 5 mV RMS |
| RTO at k = 16 | less than 1 mV RMS |

**ZERO DRIFT** ± 1.5 µV RTI/°C ± 350 µV/°C RTO

**LINEARITY** ±.01% of full scale at 100 Hz

**BANDWIDTH**

3 dB point: 2 kHz (in wideband position)

Table 1.1 - Specifications

FILTER

| | |
|---|---|
| Type | Five pole Butterworth |
| fco | 150 Hz standard (convertible to 20, 50, 100 Hz) |
| Attenuation at fco | -3 dB ± 2 dB |
| Attenuation beyond fco | -30 dB/octave to -60 dB |

INPUT IMPEDANCE

| | |
|---|---|
| Gains 16-1000 | 10 megohms, in parallel with .01 µf |
| Gains .16-10 | 2 megohms, in parallel with .01 µf |

SETTLING TIME

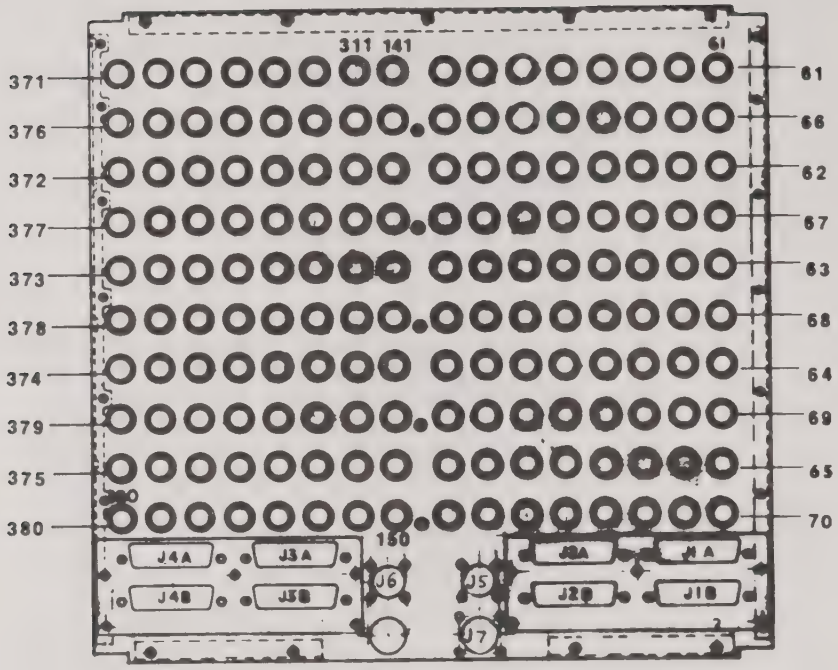
10 µsec. to ± .1% full scale from MX equivalent capacitance.

POWER REQUIREMENTS

| | |
|---|---|
| +6.5 | 1 mA |
| -6.5 | 1 mA |
| +17V | 2 mA |
| -17V | 1 mA |
| +14.9V | 10 µA |
| -14.9V | 10 µA |

Approximately 70 mW/channel

Model 160A




Model 160B

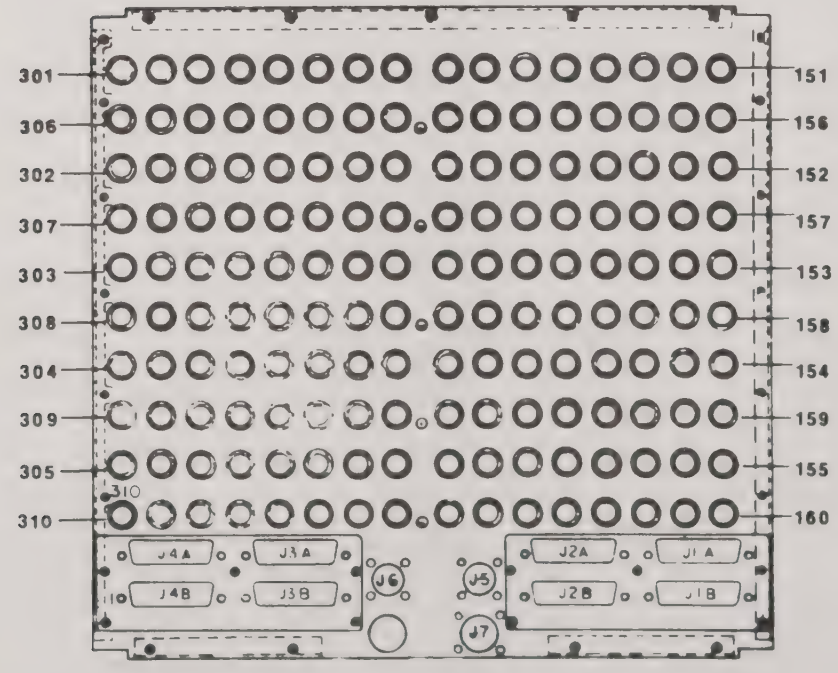



Figure 1d - Rear Panel

## 1.5 DANA MODEL 160 AMPLIFIER ENCLOSURE

Each subsystem includes two enclosures containing 160 amplifiers each. The two enclosures are designated as 160A and 160B and are identical except for connector designations. The enclosures are 14 inches high, 19 inches wide, and 12 inches deep. The 160 channels in each enclosure are identical and amplifiers can be interchanged from channel to channel.

Inputs and outputs are accessible through connectors on the rear panel:

Inputs

| 160A | 160B |
|---|---|
| CJ61 thru CJ150<br>CJ311 thru CJ380 | CJ151 thru CJ310 |

Outputs

J1A, J1B thru J4A, J4B on both enclosures (Connectors A and B of each set are wired in parallel).

Strain Gage Power - Pins E and F of input CJ connector.

The front panel has openings for zero and gain vernier adjustment for each channel. Primary power (115 volts $\pm$ 10%, 60 to 420 Hz) is isolated from case ground. The third pin of the power plug (J8-B) is connected to case ground.

The strain gage power is supplied by an external power supply through connector J7 pins B and E on the rear panel. The strain gage or excitation voltage may be monitored on the front panel at TP1 and TP2. The power for the 160 amplifiers is supplied by a shared power supply located in the lower left hand side of the enclosure. All amplifier power supply voltages are regulated. Essential voltages are electrically bussed to each amplifier channel. The input 115V AC for the amplifier power supply is fused with a 1 ampere fuse located on the front panel. The 28V DC heater power is connected through pins D and E of J8. The DC heater power is fused with an 8 ampere fuse. The fuse is located on the front panel. The 115V AC heater supply is fused with a 15 ampere fuse.

The model 160 enclosure system features a thermally insulated interior wall and electric heaters selectively placed which work in conjunction to accomplish the required warm up and stabilization characteristics. The model 160 will stabilize in a maximum of 25 minutes from $-4^{\circ}C$ and hold $50^{\circ}C$. The temperature controller can also be adjusted to stabilize at $70^{\circ}C$ in a maximum warmup time of 30 minutes. Heat losses are extremely low during the warm up period. Therefore, the heat dissipated by the electric heaters is contained within the enclosure system and is utilized to raise

the temperature of the internal members.

The AC heaters operate only during the warm up period and turn off at the determined temperature. During warm up time, the amber LO light is lit. The DC heaters are thermally controlled to maintain the determined temperature. Operation in a normal temperature range is indicated by the green NORM indicator lighting. If the temperature rises above the normal range, the red HI indicator lights. Both heater fuses will blow at a temperature of 194°F (90°C).

The temperature sensing circuit for the enclosure is located in the upper right of the enclosure. The temperature sensing is accomplished with a thermistor within a bridge network.

# SECTION 2

# INSTALLATION

## 2.1 UNPACKING AND INSPECTION

The Dana 2550 Amplifier is shipped in the Model 160 enclosure. The enclosure is placed between two forms of plastic foam and packed in a double-walled cardboard carton for shipment. This packaging is designed to absorb shocks encountered in transit. Prior to unpacking, examine the housing and inspect for any visable signs of damage. If damage is found, notify the carrier immediately.

## 2.2 AMPLIFIER POWER REQUIREMENTS

The power for the 2550 amplifier is provided by a shared power supply located on the bottom of the 160 enclosure. The power requirements for the amplifier are; plus and minus 17V DC regulated, plus and minus 14.9V DC zener regulated, and plus and minus 6.500V regulated.

> NOTE
>
> If the amplifier or enclosure has been stored for a prolonged period (5 or 6 months) without use, it is recommended that the amplifier and enclosure be operated with a variable transformer, such as a Variac, at one-half line voltage for about two hours before gradually applying full power. This is done to reform the electrolytic capacitors in the amplifier and enclosure. This procedure reduces the chances of capacitor failure.

## 2.3 INPUT-OUTPUT CONNECTIONS

Inputs and outputs to the amplifier are through two 12 pin printed circuit edge connectors at the rear of the amplifier. The mating connectors, (Dana P/N 600465) for the amplifier are mounted on printed circuit boards 410514 "A" and 410515 "B". The two printed circuit boards are mounted at the rear of the 160 enclosure. Each amplifier plugs into the corresponding two mating connectors AJ and BJ. The "J" number will correspond with the amplifier channel number. As an example, the amplifier which goes in channel "101" will connect to AJ101 which is on printed circuit

board 410514 "A". The amplifier will also connect to "BJ101" simultaneously with "AJ101". Connectors "BJ101" and "CJ101" are terminated on printed circuit board "B" 410515. Input and output connections to the amplifiers, are made through connectors on the rear panel.

### 2.3.1 Enclosure Power

Three external primary power supplies are required for the Model 160 Enclosure. They are as follows: 115 VAC ± 10% 60-420 Hz, 28 VDC and strain gage excitation voltage.

Both the AC and DC primary powers are connected to J8. Strain gage excitation voltage is connected to J7. Both the above jacks are mounted on the rear panel of the enclosure. Refer to drawings 403091, 403104 for connector pin designations. Both AC and DC primary power is fed through an RFI Filter within the enclosure. AC and DC primary power is isolated from case ground, signal common and excitation power. AC power ground is connected to the enclosure case.

#### 2.3.1.1 Power Consumption

The power consumption has two periods, warm up period and normal period. In the warmup period the power consumption for the AC Heater supply is approximately 11 amperes. The AC Heater circuit is fused with a 15 ampere fuse which is designated F2. No power is consumed in the AC Heater Circuit in the normal period. In the warmup period, the 28 VDC Heater Circuit draws approximately 6 amperes and is fused with an 8 ampere fuse. The 28 VDC Heater fuse is located on the lower front of the enclosure. The 28 VDC Heater supply draws approximately 3 amperes in the normal period at 25°C ambient. The warmup period will take about 25 minutes at an ambient of -4°C (25°F) to 50°C enclosure temperature. For both warm up and normal periods the 115 VAC Amplifier Power Supply consumes about .8 ampere. The 115 VAC Amplifier Power Supply is fused with a 1 ampere fuse. The 115 VAC Heater supply fuse and 115 VAC Amplifier power supply fuse are located on the front lower portion of the enclosure.

### 2.3.2 Input Output Signals

For permanent installations, low thermal solder (70% cadmium, 30% tin) should be used on all input connectors to minimize thermal emf's. For temporary or test setups, screw terminals or clips having low resistance may be used, taking suitable care to minimize thermal emf's. A few microvolts can be significant on high gain ranges to cause an error on the output of the amplifier. Since + signal and - signal inputs to the amplifier are symmetrical (approximately equal impedance to output common), either lead may be

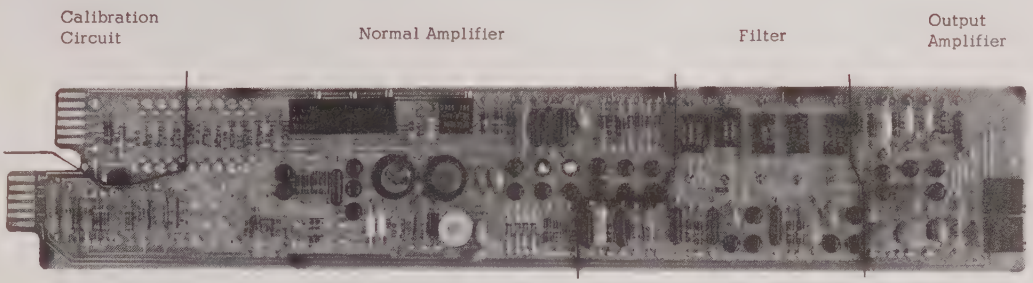



Figure 2.a - Functional Areas - 2550 Amplifier

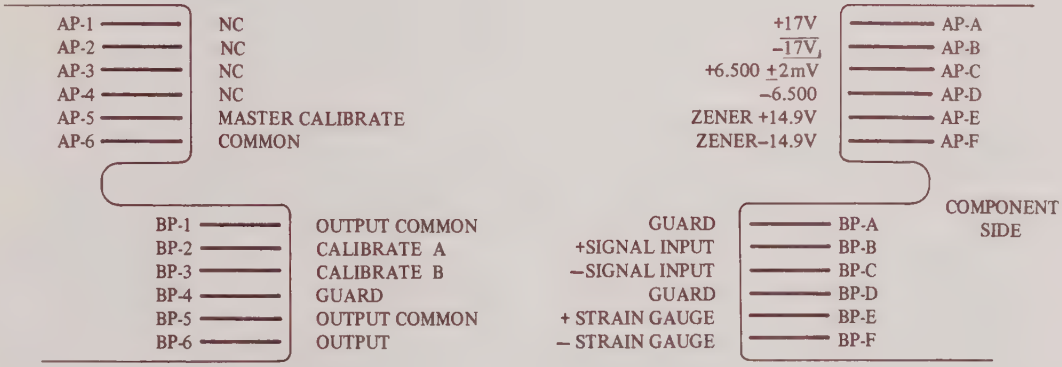



Figure 2.b - PC Board Edge Identification

connected to either side of the signal source. For phasing purposes, if + signal is positive with respect to - signal the output is positive with respect to output common.

Input leads should be a two-conductor wire enclosed in an insulated shielded cable. The shield must be soldered or connected to the amplifier edge connector at pin BP-4. If the amplifier is connected to a connector, (Dana P/N 600465) then the guard pin will be found on BJ-4. When the amplifier is in the enclosure, the guard pin comes out at pin "H" on connector "CJ" of the channel in use. The unshielded portion of the leads must be kept as short as possible. A single conductor shielded cable is recommended for output leads. Output commons for each amplifier and the power supply commons are terminated at the same point on connectors JIA, JIB through J4A, J4B. See drawing 430852 (sheet 1 of 1) in Section 6 drawings for connector pin number of output common. Another example is, channel "61" is to be wired. Channel "61" as you face the front of the enclosure will be found in the upper lefthand corner of the enclosure 160A. The amplifier in channel "61" will plug into AJ061 and BJ061 simultaneously. As you face the enclosure from the back, the input connector CJ061 will be in the upper right hand corner. The input connector pin designations for CJ061 through CJ150 and CJ311 through CJ380 are as follows:

| | |
|---|---|
| Pin A | + Strain gauge |
| B | N Input |
| C | P Input |
| D | - Strain gauge |
| E | A Calibrate |
| F | B Calibrate |
| H | Guard |

The output from channel 61 would be found at connector J1A and J1B, pin 41. The output common would be found at pins 26, 27 of J1A and J1B. Refer to drawing 430852 in Section 6 for location of output connections for other channels.

## 2.4 INITIAL CHECKOUT PROCEDURES

The amplifier is accurately adjusted and carefully inspected at Dana. The following tests check the basic characteristics of the amplifier to verify proper operation upon delivery. The type of damage that can be expected in shipment tends to produce gross malfunctions rather than minor changes in sensitive characteristics. More complete and precise tests are included in Section 5, "Maintenance". Final calibration procedures are also included in Section 5. The following items are required

to perform the initial checkout of the 2550 series amplifier:

a) Audio oscillator - Hewlett Packard 200 CD

b) Dana 2195 Test panel and 2550 series adapter cable

c) Oscilloscope - Tektronix RM503

d) AC VTVM Hewlett Packard 400L

e) Precision voltage divider ESI Dekatran DT72A

2.4.1 Initial 2195 Test Panel Set Up for the 2550 Amplifier

This checkout procedure will deal with checking the individual 2550 amplifier. The sub system will be dealt with in paragraph 2.5. It is assumed that a Dana 2195 amplifier test panel, or equivalent, is to be used for checkout of the amplifier. Dana model 2195 test panel provides a convenient means of testing and calibrating the 2550 series amplifier. The panel requires that only the amplifier input, output and power inputs be connected with no further reconnections required. All input and output configurations necessary to calibrate or test the amplifier are set up by switches and controls mounted on the panel. The panel is shown in Section 5, figure 5.a.

a) Turn on all the equipment in 2550 amplifier test set up, except the 2195 test panel. The 2195 test panel includes the power supply for the 2550 amplifier and should not be turned on until the amplifier is plugged in.

b) Adjust the oscilloscope for 5v/cm vertical sensitivity, and DC response. Center the trace on the screen. Adjust the horizontal channel to plus external input, 5v/cm sensitivity, and DC response.

c) Connect the "SCOPE VERT" from the 2195 test panel into the vertical input of the oscilloscope. Connect the "SCOPE HOR" from the 2195 test panel to the horizontal input of oscilloscope.

d) Connect the precision voltage divider as follows: the input of the precision voltage divider to the "DECADE IN" terminals on the 2195 test panel. The output of the precision voltage divider to the "DECADE OUT" terminals on the 2195 test panel. Set the voltage divider to the reciprocal of the gain of 200, which is .0050000.

e) Connect the audio oscillator to the "GEN INPUT" terminals on the 2195 test panel.

f) Connect the AC VTVM to the vertical input terminals of the oscilloscope.

g) Adjust the 2195 test panel such that:

1. The "GEN EXT" switch is in the "GEN INPUT" position.

2. The "ATTENUATOR" switch is set to the "DECADE XFMR"

3. The "FIXED VARIABLE" switch is set to "FIXED"

4. The "INPUT MODE" switch is set to "SHORT"

5. The "SOURCE UNBAL" switch is set such that the red knob is in the "SHORT" position and the black knob is in the 1K position.

6. The "GUARD OFF ON" switch is set to the "ON" position.

7. The "INPUT SELECTOR" switch is set to "INT AMP"

8. The "LOAD" switch is set such that the capacitance load (red knob) and the resistive load (black knob) are both set to "OFF".

9. The "OUTPUT MODE" switch is set to "WIDEBAND" position

10. The "FILTER KHZ" switch is set to "DIRECT".

11. The "NULL ADJ" is set such that the black knob is in the "NON INV" position.

12. The "OUTPUT SELECTOR" switch is set to "ATTEN IN".

h) Adjust the AC VTVM to the +20 dB range.

i) Adjust the audio generator to a frequency of 60 Hz with an amplitude of 13.2 dB as indicated on the AC VTVM. The output voltage will appear as a 10V PP horizontal and vertical deflection on the oscilloscope. The trace will be a diagonal line extending from the first quadrant to the third quadrant of the oscilloscope.

j) Adjust the "OUTPUT SELECTOR" knob on the 2195 test panel to the "AMP OUT" position. (CAUTION: BEFORE PERFORMING THE NEXT STEPS, BE SURE THAT THE POWER SWITCH ON THE 2195 TEST PANEL IS TURNED OFF).

k) Connect the 2550 adaptor cable to the rear of the 2550 amplifier. Connect the 2550 adaptor cable to the 2195 test panel.

l) Verify that the amplifier is at a gain (K) of 200.

m) Place the "POWER OFF-ON" switch on the 2195 test panel in the "ON" position.

n) Place the "INPUT MODE" switch to the "NON INV" position.

o) Verify that the presentation on the oscilloscope is a line extending from the second quadrant to the fourth quadrant.

p) Place the "INPUT MODE" switch to the "SHORT" position.

> NOTE
>
> All final adjustments and tests for the 2550 amplifier are taken at an ambient temperature of 50°C with the 2550 amplifier installed in the model 160 enclosure. If any minor adjustments are required, the final adjustment must be made after a 30 minute stablization period in the 160 enclosure.

2.4.2 RTO Zero Check

a) Place the "FILTER KHZ" switch on the 2195 test panel in the "DIRECT" position if the variband jumper is in position TPC on the amplifier. If the variband jumper is not in position TPC, place the "FILTER KHZ" switch in the "1" position.

b) Verify that the vertical position of the oscilloscope trace remains at zero $\pm$ 100 mV. Do not adjust the RTO zero potentiometer R73 at this time. The zero offset is due to the difference in power supply voltages and temperature difference between the 2195 test panel and the enclosure.

2.4.3 Gain Check

a) Adjust the audio oscillator to 100 Hz if the active filter cutoff frequency is 150 Hz. (Adjust to 35 Hz or 15 Hz for cutoff frequencies of 50 or 20 Hz.)

b) Adjust the amplitude of the audio to 10V PP which is +13.2 dB on the AC VTVM.

c) Place the "ATTENUATOR" on "DECADE XFMR".

d) Adjust the decade XFMR to the reciprocal of 200 (.0050000)

e) Place the "INPUT MODE" switch in the "NON INV" position.

f) Verify that the amplifier under test is in a gain of 200.

g) Compare the output signal amplitude with the signal in step 2.4.3. (b). This can be accomplished by moving the "OUTPUT SELECTOR" switch on the 2195 test panel from "AMP OUT" to "ATTEN IN" positions. The amplitude of the two signals should remain the same $\pm$ .5 dB.

2.4.4 Variband

a) Adjust the frequency of the audio generator to 150 Hz, 50 Hz or 20 Hz. Adjust the amplitude to 13.2 dB.

b) Place the "INPUT MODE" switch on the 2195 test panel in the "NON INV" position.

c) Verify that the jumper at TPC is installed.

d) Verify that the reading on the AC VTVM is +10.2 dB $\pm$ 2 dB. The pattern on the oscilloscope should be elliptical and assume an orientation in the first and third quadrants of the oscilloscope.

2.4.5 Common Mode Rejection

a) Adjust the audio oscillator to 60 Hz. Adjust the amplitude to +20 dB as indicated by the AC VTVM.

b) Place the "INPUT MODE" switch on the 2195 test panel in the "CM" position.

c) Set the oscilloscope to 5 mv/division. Verify that the pattern on the oscilloscope is a straight horizontal line.

d) Common mode rejection may be computed with the following formula:

$$\text{CMR in dB} = 20 \log \text{ of } \frac{\text{Common Mode volts PP} \cdot K}{\text{Output volts PP}}$$

e) Place the black knob of the "SOURCE UNBAL" switch on 100 ohm position. Place the red knob to "P", "N", and return the red knob to short position. Note the three voltage outputs (pp)

on the oscilloscope. The common mode rejection may be computed for each of the three conditions, use the formula in step 2.4.5 (d).

2.4.6 FET Switch Check

a) Connect a precision ohm meter to points BP-2 "A" and BP-3 "B".

b) Verify that the ohm meter reads open.

c) Connect a clip lead between points BP-3 "B" and AP-3 "C".

d) Verify that the ohm meter reads 25.000K ohm +.012K ohm.

2.5 SIGNAL CONDITIONING SUB SYSTEM

2.5.1 General

The signal conditioning sub-system (2550 amplifiers and the model 160 enclosure) may be checked in the same fashion as the individual 2550 amplifier which is outlined in Sections 2 or 5.

2.5.2 Individual Channel Check

a) Unlock and open the enclosure door. Remove the fifteen screws holding the front panel in place. Locate the access hole for the +6.5V adjustment potentiometer (R12) on the enclosure control panel assembly. The access hole is located below channel #105 on the control panel assembly. Remove the amplifier in channel #105. Insert an extender card (Dana Part Number 403242) into channel #105. Apply power to the signal conditioning subsystem. All amplifiers should be installed except channel #105. Allow the system to warmup for fifteen minutes. Refer to figure 2c. Connect a DVM to the extender card as follows: DVM common to (AJ-6) amplifier common, DVM input to (AJ-C or 3) +6.5 volts. Verify that the +6.5 volt supply is +6.500 volts $\pm$ .002V. Adjust R12 if necessary to +6.500 volts $\pm$ .002V. Remove the power to the enclosure. Remove the DVM cables from the extender card. Remove the extender card from channel #105 and insert the amplifier. Reinstall the front panel and the 15 screws.

b) Apply power to the signal conditioning sub-system. Allow the sub-system to stabilize for 30 minutes.

c) Connect the input leads from connector "CJ" of the channel under test to the input section on the 2195 test panel.

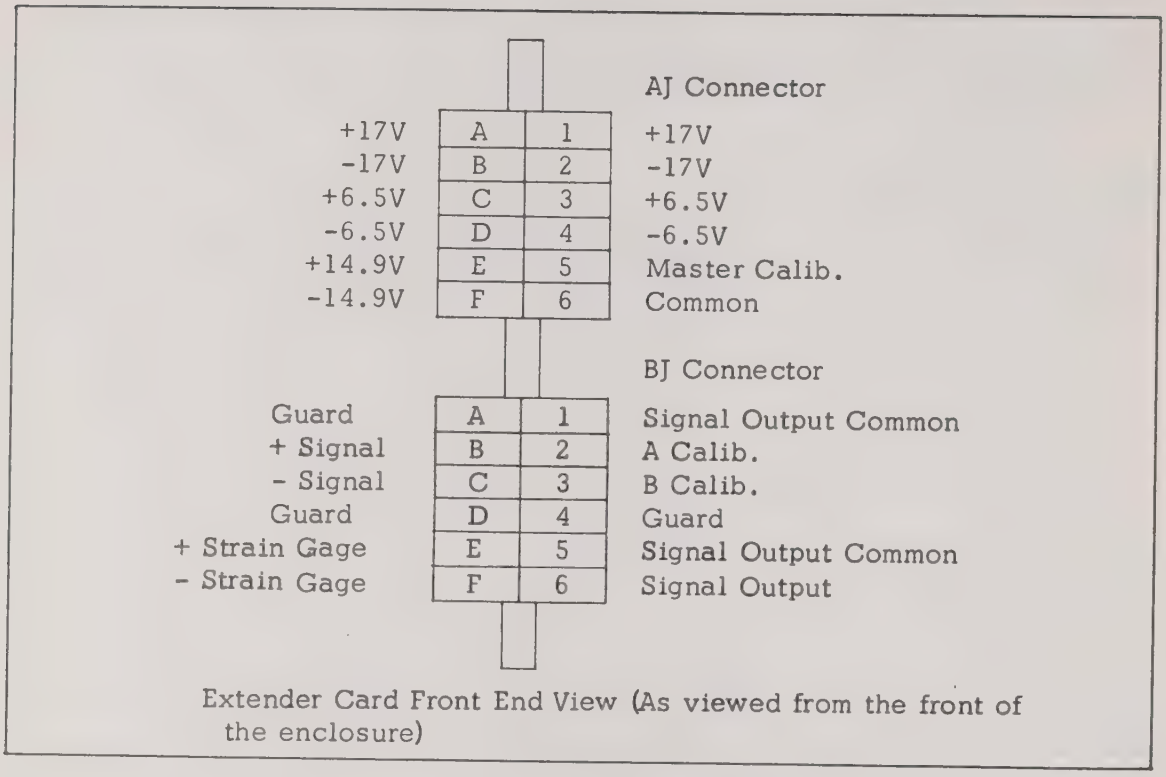

AJ Connector
+17V A 1 +17V
-17V B 2 -17V
+6.5V C 3 +6.5V
-6.5V D 4 -6.5V
+14.9V E 5 Master Calib.
-14.9V F 6 Common
BJ Connector
Guard A 1 Signal Output Common
+ Signal B 2 A Calib.
- Signal C 3 B Calib.
Guard D 4 Guard
+ Strain Gage E 5 Signal Output Common
- Strain Gage F 6 Signal Output
Extender Card Front End View (As viewed from the front of the enclosure)

Figure 2.c Extender Card

Connect as follows:

| Connector | Pin | To | 2195 Test Panel |
|---|---|---|---|
| CJ | B | - | Ext Amp. Input N |
| CJ | C | - | Ext Amp. Input P |
| CJ | H | - | Ext Amp. Input Guard |

Use a shielded pair cable for inter-connection

d) Connect the output leads from connector J1A-4A of the channel under test to the "AMPLIFIER WB" terminals on the 2195 test panel. Connect "OUTPUT COMMON" to the black "WB" terminal on the 2195 test panel. Connect the "OUTPUT" lead to the white "WB" terminal on the 2195 test panel. Use a coaxial cable for interconnection.

e) Place the "INPUT SELECTOR" on the 2195 test panel to "EXT AMP".

2.5.3 RTO Zero Channel Check

a) Place the "INPUT MODE" in the "SHORT" position.

b) Verify that the gain vernier potentiometer R76, is in it's most counter clockwise position.

c) Verify that each channel is at zero ± 5 mV. If any offset is encountered, adjust the RTO zero potentiometer R73 for zero output ± 5 mV.

2.5.4 Full Scale Output Check

a) Adjust the audio generator to 60 Hz and 10V pp output.

b) Place the "INPUT MODE" switch in the "NON INV" position. Verify that there is a non inverted signal with an output of 10V PP on each channel.

c) Place the "INPUT MODE" switch in the "INV" position. Verify that there is an inverted signal with an output of 10V pp on each channel.

d) Any other tests desired on amplifier may be performed with the use of the 2195 test panel and associated test equipment. Refer to Section 5 "Maintenance" for other tests.

2.5.5 Enclosure Mounting

The enclosure may be mounted in one of two ways. Rack mounted or vertical mounted, is used with the mounting flange assemblies in a vertical position. Four different mounting flange assemblies are required for rack mounting. Hard mount is used with the mounting flange assemblies in a horizontal position. Two different mounting flange assemblies are required for hard mounting. Two mounting flanges of each assembly type are required, making four mounting flanges for hard mounting.

2.5.5.1 Rack Mounting

For rack mounting installations, refer to drawings 400952 and 453060 in Section 6 Drawings. Mount flange assemblies 403086, 403087, 403088 and 403089 as shown in drawing 400952.

2.5.5.2 Hard Mounting

For hard mounting, use two mounting flange assemblies 453267 and 453268. Mount one 453267 on the top right side and the other 453267 on the lower left side of the enclosure. Mount one 453268 on the lower right side and the other 453268 on the top left side of the enclosure.

# SECTION 3

# OPERATION

## 3.1 MODES OF OPERATION

The Dana Amplifier can be used in any of the four operating modes illustrated below:

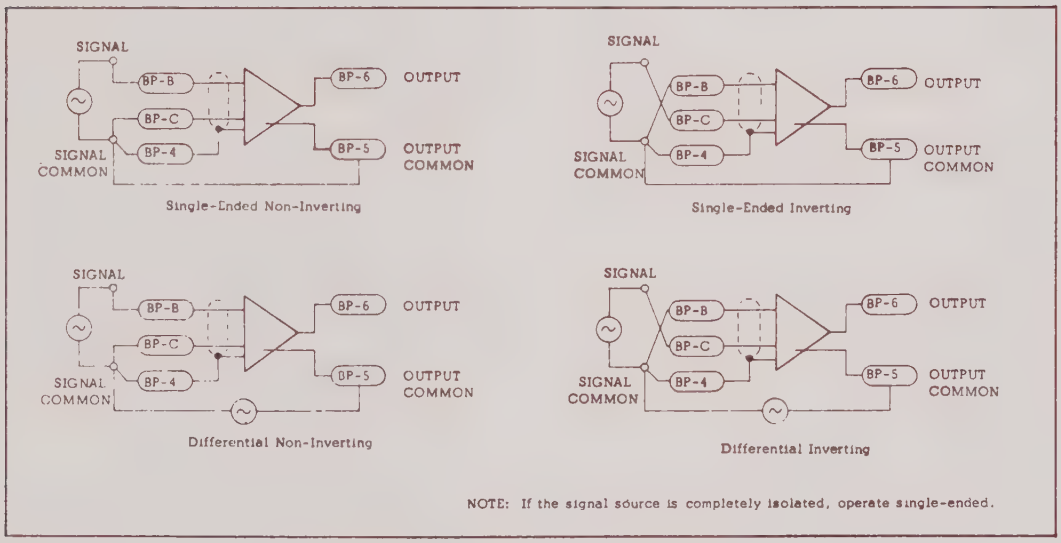



Figure 3.a - Modes of Operation

## 3.2 CONTROLS

### 3.2.1 Balance or Zero Adjustment

The balance or zero adjustment is accomplished by two different methods depending on the type of input mode configuration. The balance or zero potentiometer R73 accomplishes the same result. That is, to vary the output plus and minus of zero. When the amplifier is to be used with a bridge input, R73 is considered to be a balance control. The jumpers are as follows: "TPH" is installed, jumpers TPE, TPD are in position 2 and a resistor of proper value dependent on balance range desired, is to be installed at TPF position 2. In other input configurations R73 is considered to be a zero control. Jumpers TPD and TPE are in position 1, a 402K resistor is installed in TPF position 1, and Jumper TPH is removed. The zero or balance adjustment is located on the front edge of the 2550 amplifier board. Refer to figures 3b, c, d for location. For this zero adjustment, we will assume that the amplifier is installed in the Dana Model 160 enclosure.

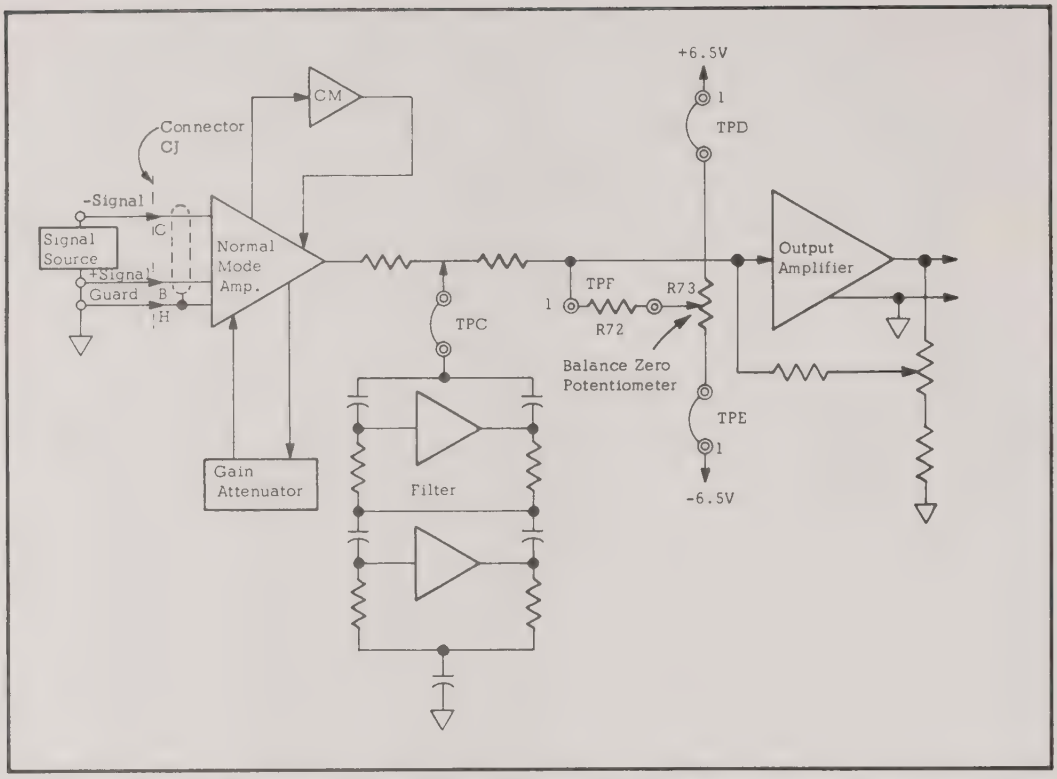



Figure 3.b Balance/Zero Potentiometer in Zero Configuration

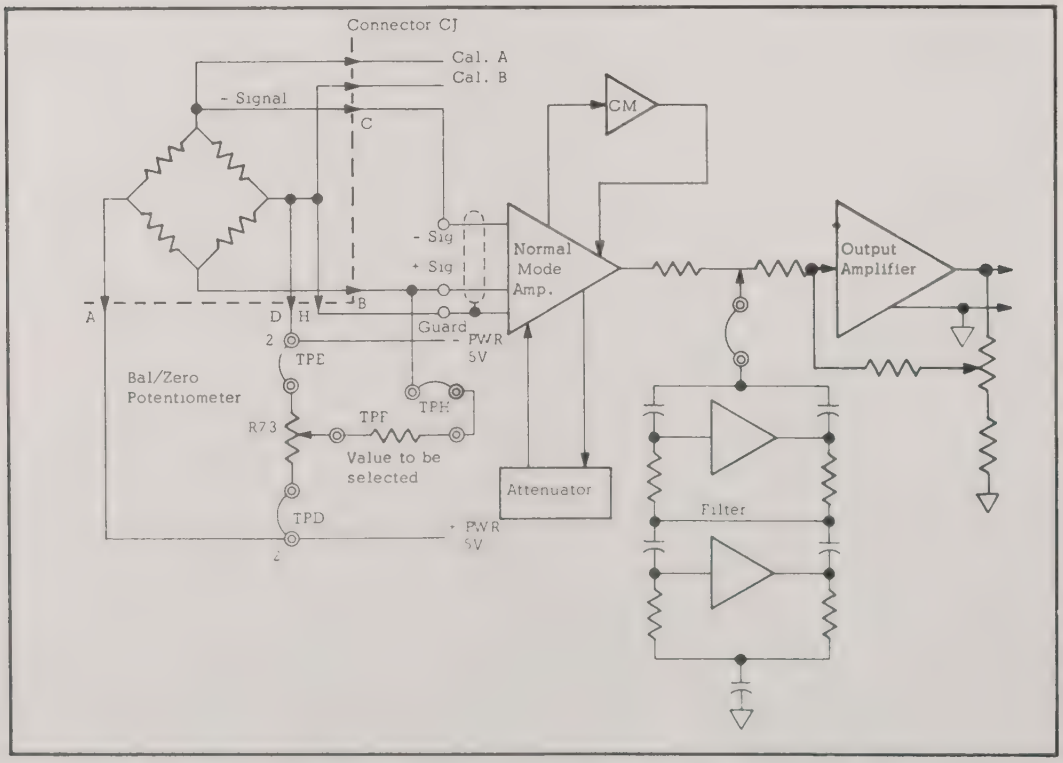



Figure 3.c Balance/Zero Potentiometer in Bridge Balance Configuration

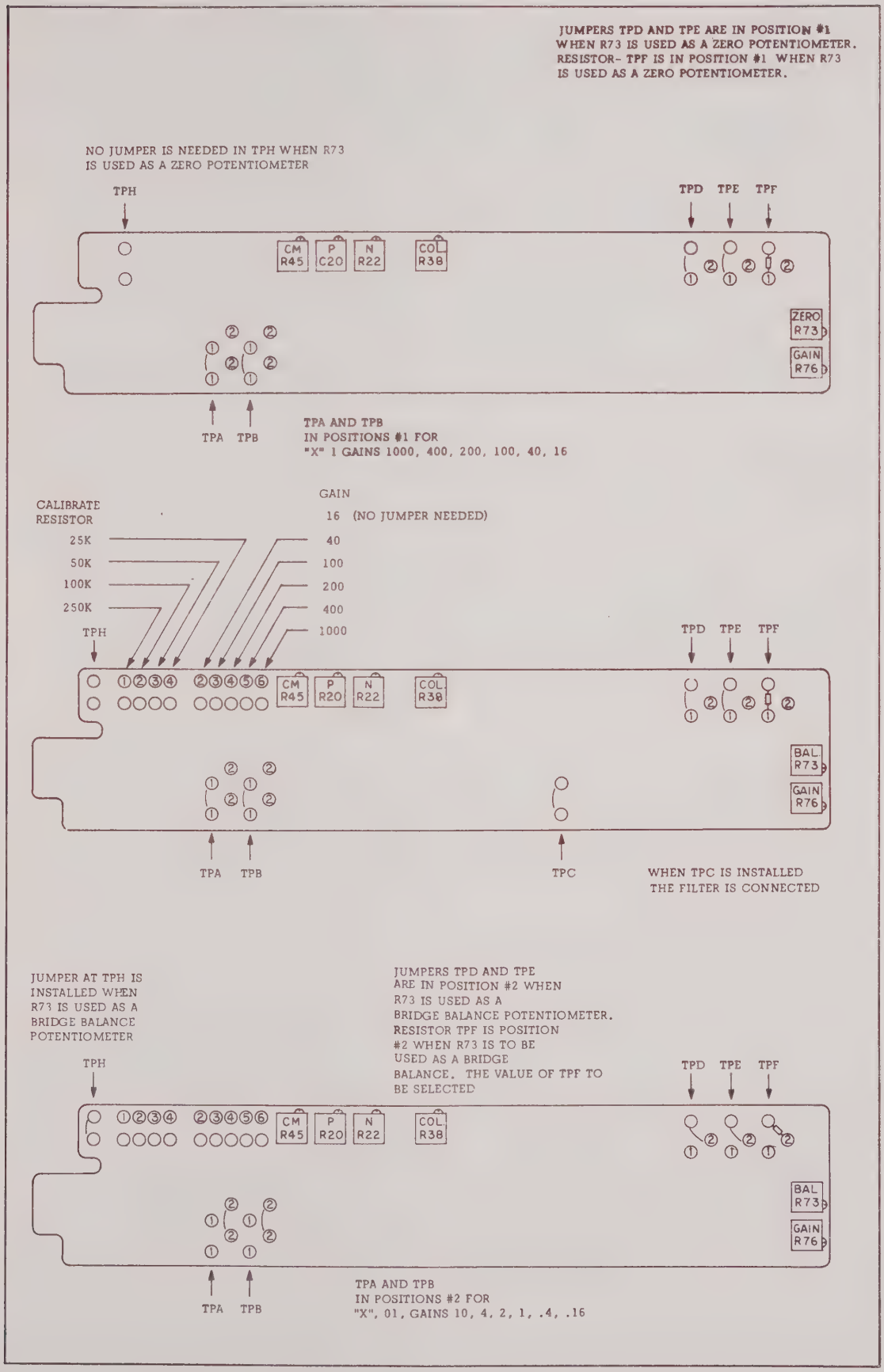

JUMPERS TPD AND TPE ARE IN POSITION #1 WHEN R73 IS USED AS A ZERO POTENTIOMETER. RESISTOR- TPF IS IN POSITION #1 WHEN R73 IS USED AS A ZERO POTENTIOMETER.
NO JUMPER IS NEEDED IN TPH WHEN R73 IS USED AS A ZERO POTENTIOMETER
TPH
TPD TPE TPF
CM R45
P C20
N R22
COL R38
ZERO R73
GAIN R76
TPA TPB
TPA AND TPB IN POSITIONS #1 FOR "X" 1 GAINS 1000, 400, 200, 100, 40, 16
CALIBRATE RESISTOR
25K
50K
100K
250K
GAIN
16 (NO JUMPER NEEDED)
40
100
200
400
1000
TPH
TPD TPE TPF
CM R45
P R20
N R22
COL R38
BAL R73
GAIN R76
TPA TPB
TPC
WHEN TPC IS INSTALLED THE FILTER IS CONNECTED
JUMPER AT TPH IS INSTALLED WHEN R73 IS USED AS A BRIDGE BALANCE POTENTIOMETER
JUMPERS TPD AND TPE ARE IN POSITION #2 WHEN R73 IS USED AS A BRIDGE BALANCE POTENTIOMETER. RESISTOR TPF IS POSITION #2 WHEN R73 IS TO BE USED AS A BRIDGE BALANCE. THE VALUE OF TPF TO BE SELECTED
TPH
TPD TPE TPF
CM R45
P R20
N R22
COL R38
BAL R73
GAIN R76
TPA TPB
TPA AND TPB IN POSITIONS #2 FOR "X", 01, GAINS 10, 4, 2, 1, .4, .16

Figure 3.d 2550 Amplifier Bifurcated Terminal Location

a) Apply power to the amplifier and any adjoining heat producing equipment. Allow the amplifier to stabilize for approximately 30 minutes. Note: It is assumed that the input connections have been wired to the input sensing device. If this is not the case, then set the amplifier up as follows:

1. Place jumpers TPD, TPE in position 1. Remove jumper TPH. Place R72 in position 1.

2. Short the + signal input to the - signal and to guard. Return these three leads to output common.

b) Connect a voltmeter or oscilloscope to the amplifier's output and output common.

c) Adjust the zero or balance potentiometer R73 for zero ± 5. mV

3.2.2 Gain Vernier Adjustment

This is a screwdriver adjustment which serves as a vernier adjustment of the gain selected by the gain position. The adjustment varies each gain position by a factor of + 2.5 providing continous gain selection through out all available ranges. The gain vernier R76 is located on the lower front portion of the 2550 amplifier board.

3.2.3 Other Adjustments

Four other potentiometer adjustment controls are provided for use if the need arises. They are common mode amplitude error (R45), RTI zero 1st stage collector (R38), RTI P source (R20), and RTI N source (R22). Trimmer (C11) is provided for common mode quadrature error. The operation of these controls are described in SECTION 5 MAINTENANCE.

## 3.3 USE OF BIFURCATED TERMINALS

a) Calibrate positions 1 through 4 are selected by using a jumper between the bifurcated terminals. Refer to figure 3.d for reference. Positions 1 through 4 select a shunt resistor for input bridge circuit. The Calibrate Circuit is used only when the Master Calibrate button is depressed.

b) Gain positions 2 through 6 are selected by using a jumper between the bifurcated terminals.

c) The "XI" and "X.01" positions are selected with jumpers at TPA and TPB position 1 or 2. "X1" (selected gain times one) position is selected by placing TPA and TPB in position 1. Gain positions 1 through 6 are 16, 40, 100, 200, 400 and 1000 in the "X1" position. "X.01" (selected gain times .01) position is selected by placing TPA and TPB in position 2. Gain positions 1 through 6 are; .16, .40, 1.0, 2.0, 4.0 and 10.0 in the "X.01" position.

d) The variband filter may be connected in or out by the use of the jumper at TPC. The variband is adjusted at Dana for 150 kHz, 50 Hz or 20 Hz. The variband may be modified for different cutoff frequencies by replacing C14, C16, C17, C19 and C20, with different value capacitors. Refer to figure 4.m.

e) The jumpers around the balance/zero control TPH, TPF, TPD, and TPE are discussed in paragraph 3.2.1 balance or zero adjustments.

## 3.4 OPERATING PROCEDURES

After installation of the amplifier as described in "Section 2 "Installation", operation consists simply of selecting the appropriate gain, variband cutoff frequency, bridge shunt resistor postion, and mode of zeroing the amplifier. The amplifier is ready for use immediately with zero stability achieved within 30 minutes in the subsystem.

## SECTION 4

## CIRCUIT DESCRIPTION

### 4.1 INTRODUCTION

This section contains an electrical description of each circuit in the amplifier. A block diagram of the Model 2550 is shown in Figure 4.a

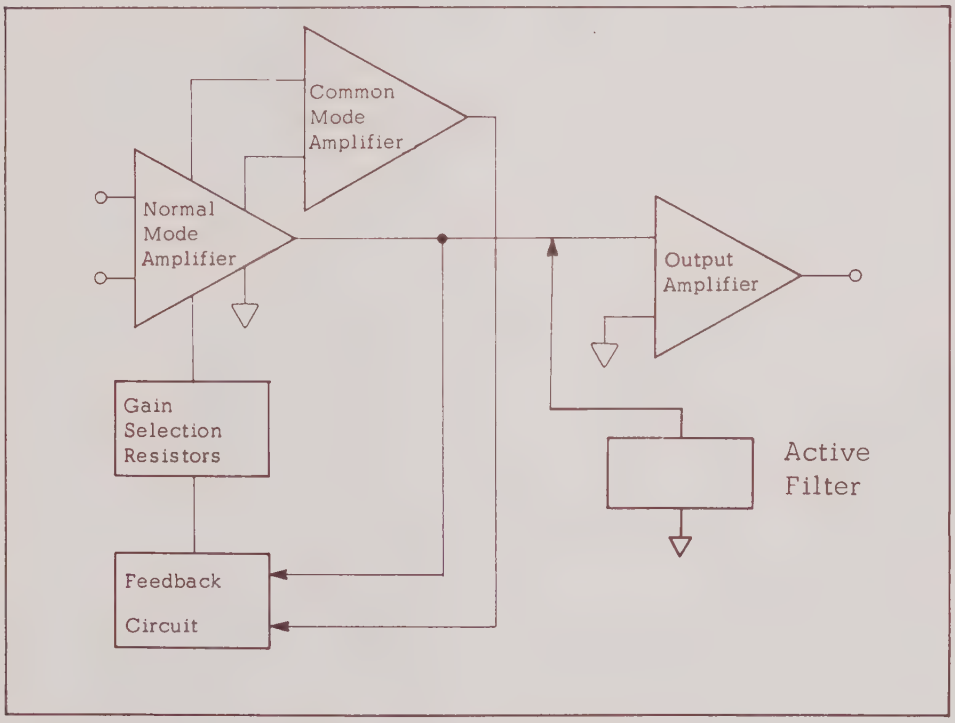



Figure 4.a - Block Diagram

The forward loop consists of the Input Amplifier and the output Amplifier. The loop is closed by the feedback network. The Input Amplifier amplifies the potential difference between the two inputs. When one input goes positive and the other input goes negative with respect to common, the output of the amplifier is proportional to the difference of the amplitudes. These signals are referred to as "normal mode signal" (also referred to as "difference" or differential signals). The potentials common to both inputs are referred to as "common mode signals" and are rejected by the amplifier. The normal mode signals and the common mode signals are defined below.

$$\text{Normal Mode Signal} = e_1 - e_2$$

$$\text{Output } (E_O) = (e_1 - e_2)\ (\text{Gain})$$

$$\text{Common Mode Signal} = \frac{e_1 + e_2}{2}$$

In single ended operation, a signal is applied to one input while the other input is common; therefore, the output is proportional to the amplitude of the one signal applied.

Figure 4.b shows the amplifier responding to normal mode signals and rejecting the common mode signal (one-half) of the bridge supply voltage. In practical applications, there would be additional common mode potentials due to stray fields and other causes. These potentials represented by "$e_x$" are also rejected.

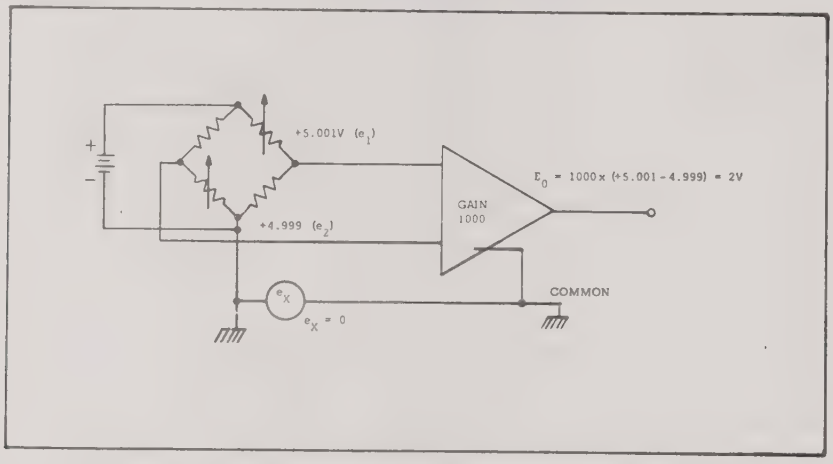



Figure 4.b - Normal Mode and Common Mode Response

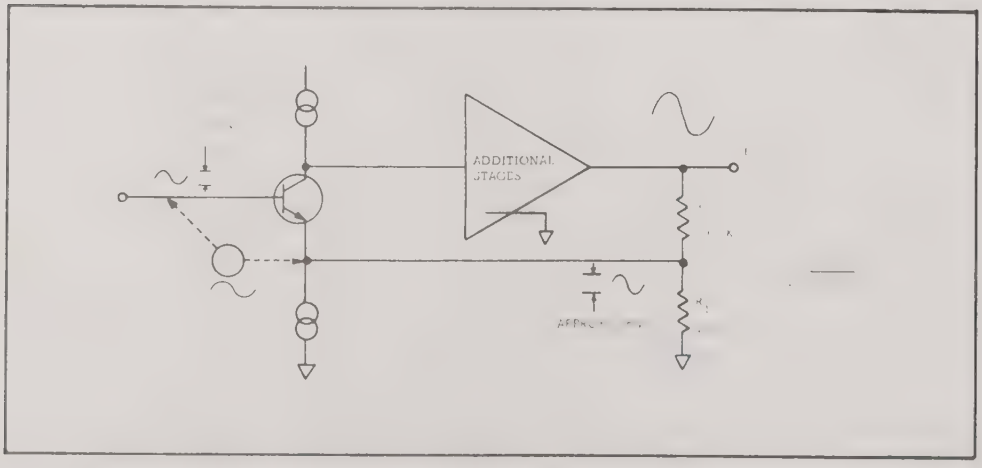



Figure 4.c - Simplified Potentiometric Amplifier (Gain of 1000)

### 4.1.1 NORMAL MODE AMPLIFIER

Figure 4.c shows a potentiometric amplifier. This type of amplifier is called a potentiometric device, since the feedback achieves a high effective input impedance by circuit action whose effect is similar to the common "null balance" approach to precision measurements. In both cases, the effective input impedance approaches infinity at null. In the potentiometric amplifier, impedance is limited by factors such as leakage and practical values of loop gain.

Examining the feedback system, it can be seen that the feedback is of proper phase to cancel the effect of the input signal; however, the cancellation leaves a small "error" signal of sufficient magnitude to support the 5-volt output. In the example, if the open loop gain (gain without feedback) of the circuit were 140 dB, the approximate residual error signal would be $5V/10^7$ or 0.5uV ($e_e$ in the figure).

To achieve the desired gain stability and linearity, the open loop gain is considerably greater than the closed loop gain. By keeping this ratio sufficiently high, the "closed loop" or "net gain" is essentially determined by the feedback elements alone.

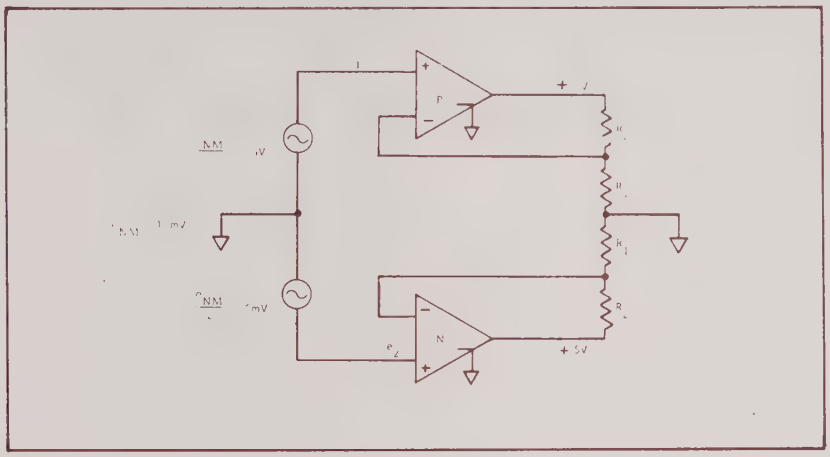


Figure 4.d - Potentiometric Amplifiers in Differential Configuration

Figure 4.d shows two potentiometric amplifiers connected in a differential configuration. One-half of the normal mode voltage ($e_{NM}/2$) appears at $e_1$ while the other one-half of the normal mode voltage appears at $e_2$. As in Figure 4.c, a 5 millivolt signal at each of $e_1$ and $e_2$ will be 5 volts output at each potentiometric amplifier. With the differential amplifier stage as shown in Figure 4.e, the outputs of the balanced differential stages are combined in the summing amplifier which transfers one directly and inverts the other. This is in keeping with the normal mode signal characteristics of $e_1 - e_2$. Signals of common polarity or phase will cancel at the summing stage, the degree of cancellation dependent on their relative magnitudes.

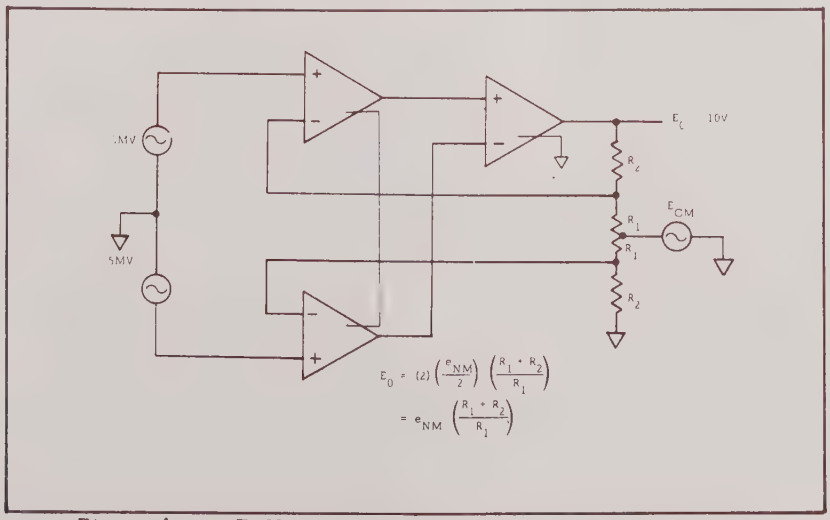



Figure 4.e - Differential Stage for Summation of Inputs

Input lines ($e_1$, $e_2$) are connected to the bases of a pair of matched silicon transistors (dual transistors in a single case) and circuit parameters are adjusted to obtain equal characteristics in each stage. A unique aspect of the circuit is the technique employed in controlling these parameters for stable operation over wide temperature ranges.

### 4.1.2 COMMON MODE AMPLIFIER

Although the Normal Mode Amplifier provides a degree of common mode rejection (CMR = 60 to 70 dB with balanced source), it is insufficient for high accuracy data systems. The primary deficiency of the circuit is the low impedance between the input lines and common - too low to materially reduce common mode currents. This deficiency is overcome by the use of a separate Common Mode Amplifier (CMA) which senses the common mode voltage at the input and forces the emitters of the "input pair" of the normal mode amplifier to the same potential (neglecting bias). This "bucking" voltage allows very little current to flow from either input to output common, increasing the intrinsic impedance to common.

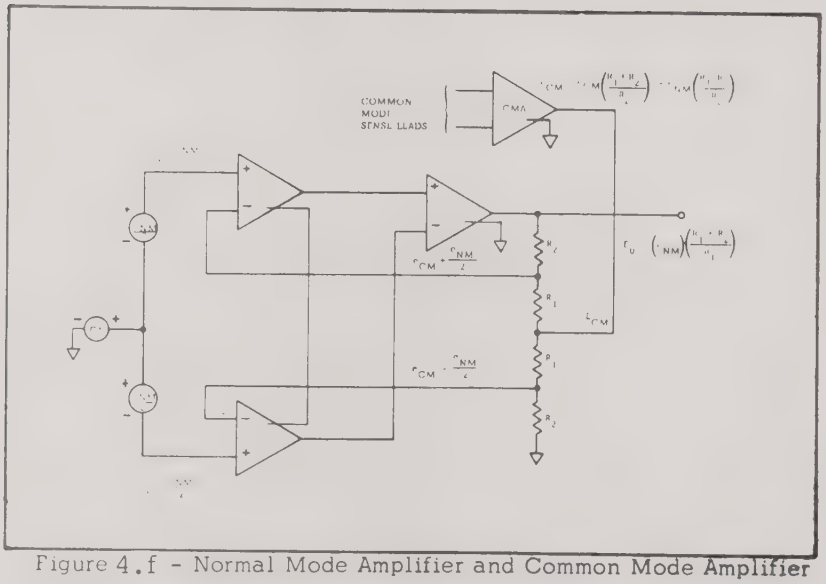



Figure 4.f - Normal Mode Amplifier and Common Mode Amplifier

Figure 4.f shows the relationship of the normal mode amplifier and the common mode amplifier. The output of the common mode amplifier ($E_{CM}$) is connected to the junction of the $R_1$ resistors.

The voltages, $e_1$ and $e_2$, appear at the voltage divider as shown in Figure 4.f. The "bucking" voltage is supplied by the common mode amplifier.

Consider the upper-half of the voltage divider and the lower-half of the voltage divider as shown in Figure 4.g. The upper-half of the voltage divider is bounded by the two voltages $E_O$ and $E_{CM}$. The voltage at $E_{01}$ is equal to

$$E_{01} = E_O - \left(E_O - E_{CM}\right)\left(\frac{R_2}{R_2 + R_1}\right)$$

and is the "bucking" voltage to effectively cancel $e_{CM} + \frac{e_{NM}}{2}$.

The lower-half of the voltage divider is bounded by $E_{CM}$ and common. The voltage at $E_{02}$ is equal to

$$E_{02} = E_{CM}\left(\frac{R_2}{R_1 + R_2}\right)$$

and is the "bucking" voltage to effectively cancel

$$e_{CM} - \frac{e_{NM}}{2} .$$

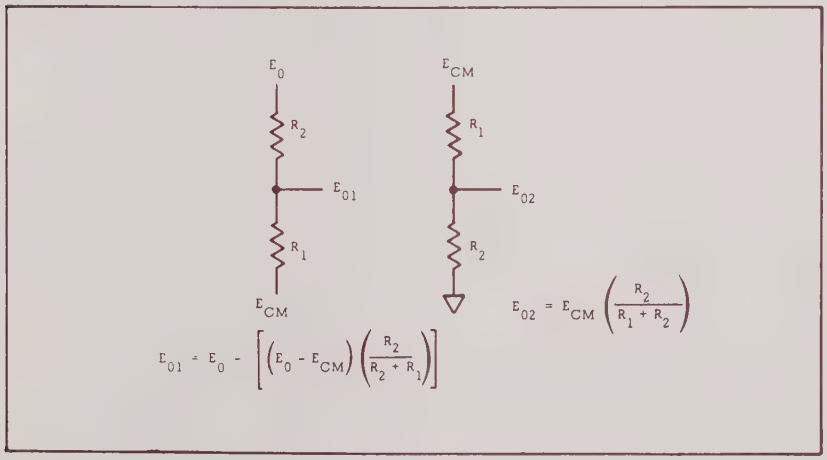



Figure 4.g - Voltage Dividers

The common mode voltage ($E_{CM}$) from the common mode amplifier required to satisfy the equations is

$$E_{CM} = e_{CM}\left(\frac{R_1 + R_2}{R_2}\right) - e_{NM}\left(\frac{R_1 + R_2}{2R_2}\right)$$

The gain of the normal mode amplifier is set by inserting a resistor $R_X$ as shown in Figure 4.h. Resistor $R_X$ does not influence the value of $E_{CM}$ and may be varied without interfering with the common mode compensation.

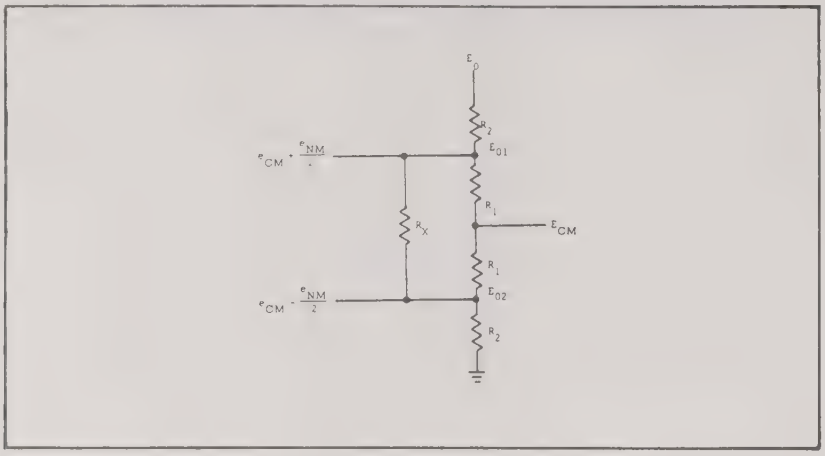



Figure 4.h - Gain Set

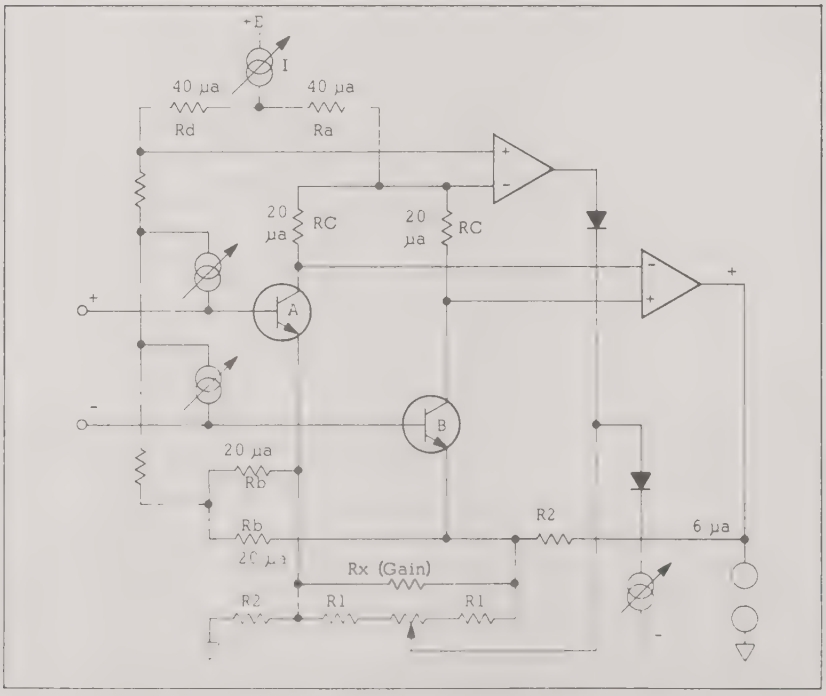



Figure 4.i - Input Amplifier

## 4.2 INPUT AMPLIFIER

The Input Amplifier can now be shown as in Figure 4.i . Differential input signals cause out-of-phase signals to be developed across the input pair's respective collector resistors Rc. Under these conditions, the drop across the collector summing resistor (Ra in Figure 4.i ) remains constant; however, a voltage source common to both input lines ($e_{CM}$) causes in-phase collector current variations which add through Ra and produce a signal proportional to the common mode potential, providing an input to the CMA. As illustrated in Figure 4.i , the CMA couples a feedback signal to the emitters of the input pair through resistors R1. This signal is of the proper phase to cancel the effect of the input potential and maintain the sum of the two collector currents constant. Cancellation is complete except for a small residual error voltage necessary to maintain the output of the CMA very near the common mode potential (ignoring feedback insertion loss).

For convenience, the Common Mode Amplifier has been described as if it were a single-ended device referenced to ground. However, the CMA is a differential amplifier much like the Normal Mode Amplifier and, as such, responds to the difference between its input terminals. In the actual circuit, one of the CMA input terminals is connected to the lower side of the input stage collector summing resistor and the other to a passive divider connected between the input pair emitters and the top of the collector summing resistor (Figure 4.i ).

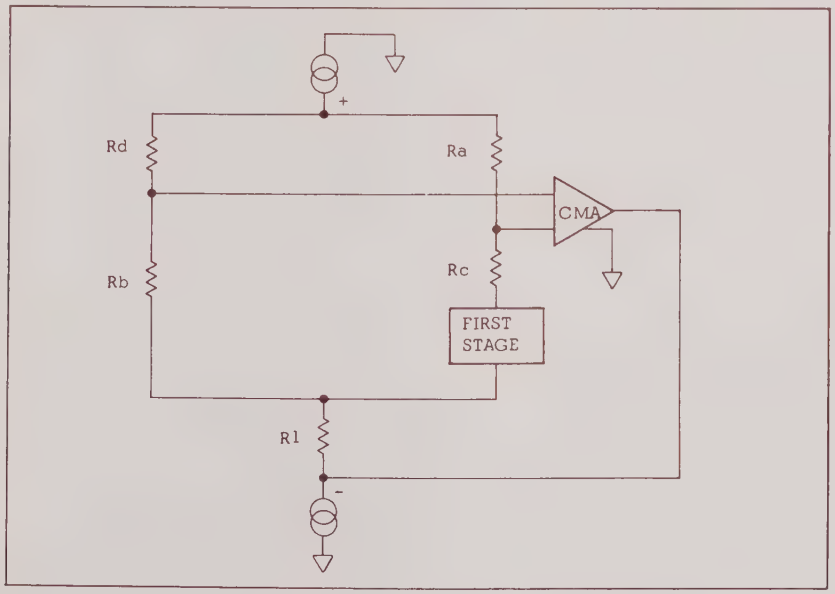



Figure 4.j - Equivalent Bridge

If this circuit is closely examined, it can be seen that the various circuit elements form a simple bridge. This identity is established in Figure 4.j . In operation, the application of a common potential to the input transistors tends to unbalance the bridge by changing the conductance of the input pair. This effect is opposed by driving the lower end of the bridge (or the emitters of the input pair) with the output of the CMA. This feedback effectively cancels the change in conductance and restores the bridge to balance.

As previously stated, the parameters of the input stage are carefully adjusted for nearly identical characteristics. Once established, they cannot be allowed to change when the circuit is subjected to common mode potentials. From Figure 4.j it can be seen that the entire input circuit is floating between two constant current generators. Since it has been established that the active elements in the bridge circuit (transistors) are continuously balanced against passive elements (Rd, Rb, Ra, Rc), it becomes apparent that the constant current sources will also serve to maintain constant voltage conditions across the bridge (constant I x constant R = constant E). This means that, as the lower part of the bridge is driven up and down synchronously with the common mode potentials, the voltage at the top of the bridge varies with the same relative magnitude. This "bootstrapping" effect raises the intrinsic common mode rejection of the input pair to the high values required for high accuracy systems.

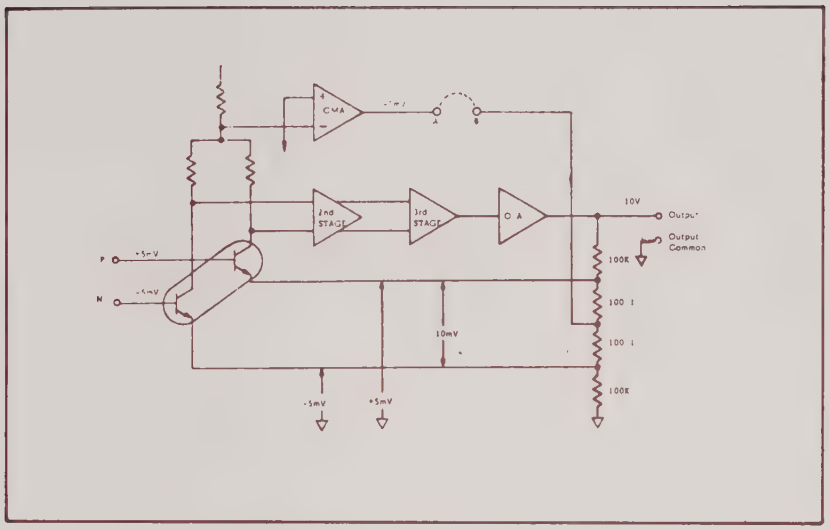



Figure 4-k - Equivalent Feedback Network for Gain of 1000

### 4.2.1 **FEEDBACK CIRCUIT**

The differential input of the amplifier requires a feedback network slightly more complex than the simple divider that was shown in Figure 4.c. To illustrate, consider the case where one input is connected to a positive signal and the other to a negative signal. It would appear that the proper bipolar feedback for both inputs could not be derived from a single output terminal; however, this is not the case.

Figure 4.k shows the equivalent feedback network of the amplifier. For the purpose of the initial discussion, assume no connection between points A and B, and that the amplifier has somehow arrived at the proper ten-volt output for a ten-millivolt input (gain of 1000). It can be seen that the voltage difference between the two feedback lines is the required 10 millivolts; however, both lines are approximately +5 volts above common. This is obviously intolerable and the circuit will not function until a connection is made between points A and B. It should be emphasized that the +5 volts is common to both input transistors and would tend to unbalance the common mode bridge just as an external common mode potential would do. The only difference in the two situations is the fact that the "feedback" common mode voltage is internally generated and tends to drive the input emitters in lieu of the bases. The latter results in one less phase inversion for internally generated common mode signals, producing an output from the CMA fo the opposite output which goes negative until the feedback lines become approximately +5 millivolts and -5 millivolts with respect to common.

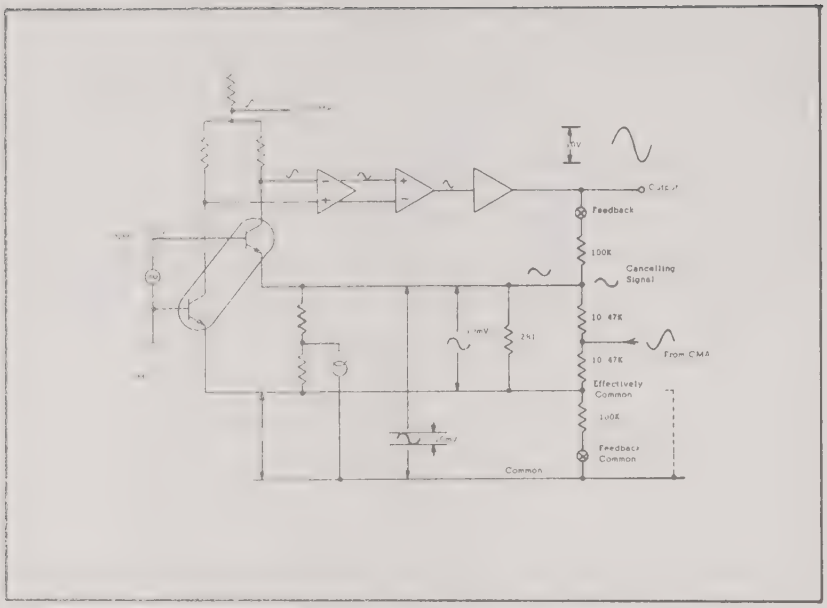



Figure 4.1 - Forced Internal Symmetry

It can now be seen that the CMA will not tolerate the bridge to be unbalanced at any time, whether the common mode potential is introduced internally or externally. More specifically, the collector currents are never permitted to shift in the same direction but can only vary by equal and opposite amounts in response to differential input signals. This fact holds true regardless of the symmetry of the input signals. For example, consider the situation where one input is tied to common and the other is driven with a 10 millivolt AC signal. The CMA assumes the proper signal level so that equal and opposite error signals exist between the base and emitter of each input transistor. The final quiescent conditions are shown in Figure 4.1

### 4.2.2 ADDITIONAL CIRCUIT DETAILS

For ease of explanation, several circuit details were intentionally overlooked. Specifically, the diagrams used to illustrate certain fundamental points inferred a quiescent voltage level of zero at several points that are normally several volts positive or negative with respect to ground. Circuit operation as described is fundamentally accurate except that signal levels are relative to the initial conditions. The static bias condition of the input pair is of particular interest since it is related to input current uncertainty. These stages are initially forward biased and, though the base idling currents are quite low, they would develop an offset voltage if allowed to flow through the external signal source resistance.

To minimize this effect, each input line is connected to a source that shunts this current to the amplifier's internal supplies. An adjustment is provided for each input line, permitting the input current to be periodically rezeroed in the field. To prevent common mode loading, these sources are made from adjustable constant current generators which are connected between the two current generators which operate the first stage. Since both input leads and the collector supply move together with the common mode potential, the current through the source generators remains very nearly constant. This infers that the impedance to common potentials is a large magnification of the already intrinsically high output impedance of the constant current generators which provide the drive to each base lead (on the order of 1000 megohms); and also points out that the quiescent base current is virtually undisturbed by common mode potentials.

Another important point is the relationship between the magnitude of the common mode potential and the voltage level at the output of the CMA. If the source of common mode is external, the output of the CMA is 10% greater than the applied voltage; if the source is internal (one-half of the output signal), the output of the CMA is $-E_{out}/20$. This relationship is solely determined by the ratio of the respective feedback resistors.

| $f_{co}$ | $C_{14}$ | $C_{16}$ | $C_{17}$ | $C_{19}$ | $C_{20}$ |
|---|---|---|---|---|---|
| 20 Hz | .165 | .352 | .112 | .165 | .135 |
| 50 Hz | .066 | .141 | .045 | .066 | .054 |
| 150 Hz | .022 | .047 | .015 | .022 | .018 |

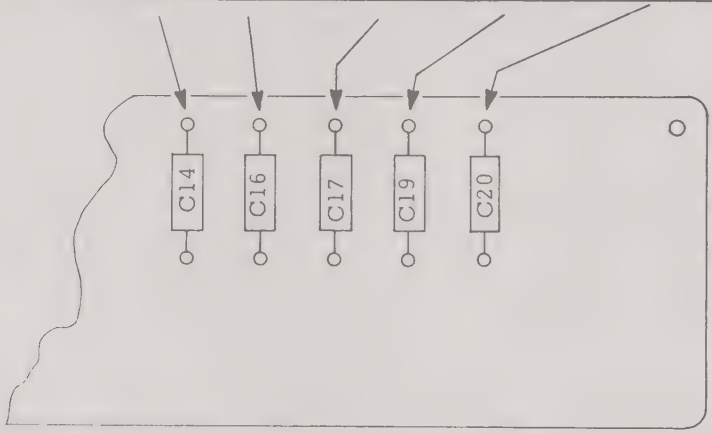



Figure 4.m - Filter Capacitor Values

Capacitor values in microfarads for various $f_{co}$'s for 2550 5-pole Butterworth filter:

Capacitor values for any desired cutoff frequency below 150 Hz may be calculated by the expression:

$$C_i\ (f_{co}') = \frac{f_{co}}{f_{co}'} \times C_i\ (f_{co})$$

Where: $C_i$ is $C_{14}$, $C_{16}$, $C_{17}$, $C_{19}$, or $C_{20}$

$f_{co}$ = known cutoff frequency
$f_{co}'$ = new cutoff frequency

Example:

$$C_{14}\ (20\ Hz) = \frac{150\ Hz}{20\ Hz} \times C_{14}\ (150\ Hz)$$

$$= 7.5 \times .022\ \mu f = .165\ \mu f$$

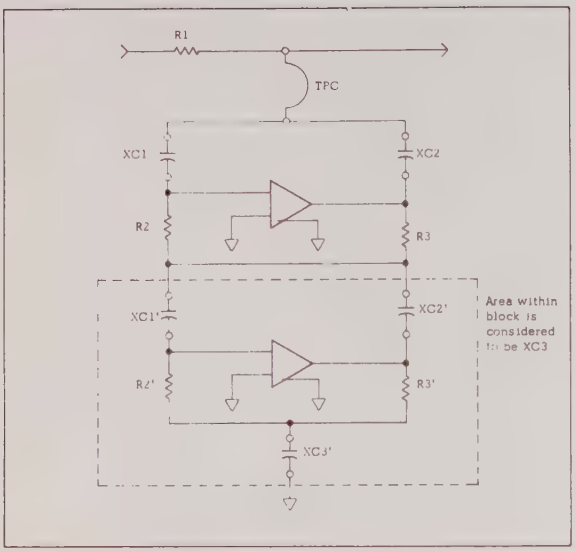



Figure 4.n - Active Admittance Filter

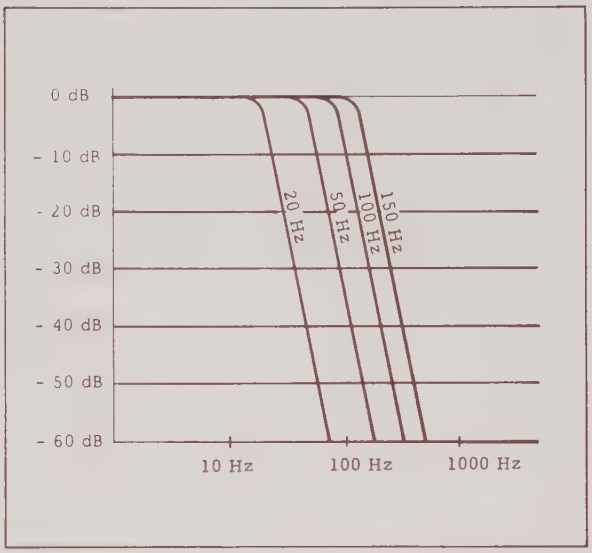



Figure 4.o Filter Cutoff

## 4.3 VARIBAND FILTER

The variband filter section is composed of transistors Q21 through Q26. The filter is an active admittance type filter with a Butterworth response. The filter can be disconnected from the signal path by removing the wire jumper TPC from the befurcated terminals. The filter has a cut off of 150 Hz as a standard cutoff frequency (-3 dB response). The filter is adjustable to cutoff frequencies of 150 Hz and lower by removing the five capacitors (C14, C16, C17, C19 and C20) from the bifurcated terminals, and inserting a different value set. The set of capacitors may be changed to the desired roll off frequency. Refer to the table 4.m for the value and location. The design of the active filter (shown in figure 4.n) is centered around two operational amplifiers whose output potentials are determined by XC1 and XC1′ acting as the summing reactances and R2, R2′, R3 R3′, and XC3, XC3′ forming the feedback networks. The level of the output potential determines the amount of signal to be shunted to ground. The gains of the operational amplifiers employed in the active filter, are frequency dependent since the impedance of XC is frequency dependent. At very low frequencies, approaching DC, the capacitive reatance of the XC1, XC2 and XC3 approaches infinity. Under these conditions the gains of the operational amplifiers are essentially zero.

As the input frequency is increased, the gain of the operational amplifier increases due to the reduction in the value of XC. As a result of the reduction in the value of XC, the amplitude of the signal increases on the input of the amplifiers. This in turn changes the output level of the two operational amplifiers and causes more signal to be shunted to ground. As fco is reached, the filter offers a lower impedance to the signal path. At frequencies 10 times the cutoff frequency and above, the reactances of XC1, XC2 and XC3 are very low. The impedance presented by the filter is very low and shunts most of the signal to circuit common, dropping it across R1.

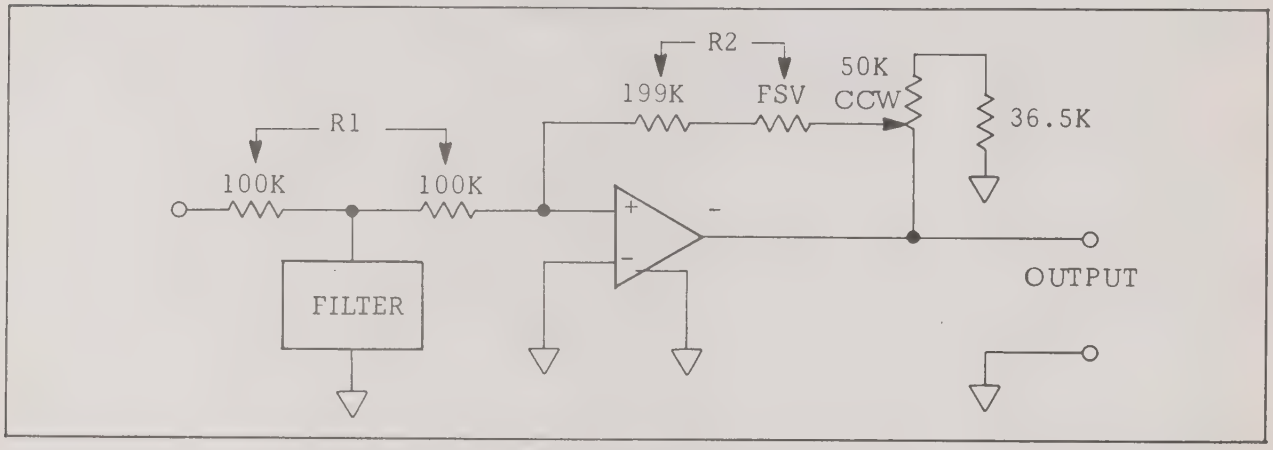



Figure 4.p - Gain Vernier in CCW position

$$\text{Gain (K)} = \frac{Eout}{Ein} = -\frac{R2}{R1} = \frac{200K}{200K} = -1$$

## 4 OUTPUT AMPLIFIER

The output amplifier is composed of transistors Q27 through Q31. The amplifier is a single ended operational amplifier with a gain of one with the gain vernier in its counter clockwise position. When the gain vernier is in a clockwise position, the gain of the output amplifier is - 2.5.

A zero potentiometer can be connected into the summing node of the output amplifier for zeroing the output. This is accomplished by placing R72 in position "1". Adjustment of the zero potentiometer causes a minute current to flow into or out of the summing node, thus causing the output to go plus or minus of zero.

The gain equations are shown in figure's 4.p,q for full ccw and cw positions of the gain vernier.

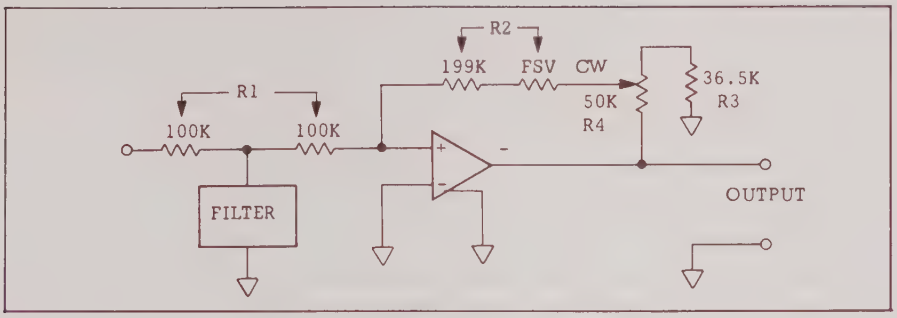



Figure 4.q - Gain Vernier in CW position

$$K = \frac{Eout}{Ein} = -\frac{R2}{R1}\left(1 + \frac{R4}{R2} + \frac{R4}{R3}\right)$$

$$K = \frac{Eout}{Ein} = -\frac{200K}{200K}\left(1 + \frac{50K}{200K} + \frac{50K}{36.5K}\right)$$

$$K = \frac{Eout}{Ein} = -1\ (1 + .25 + 1.37)$$

$$K = \frac{Eout}{Ein} = -2.62$$

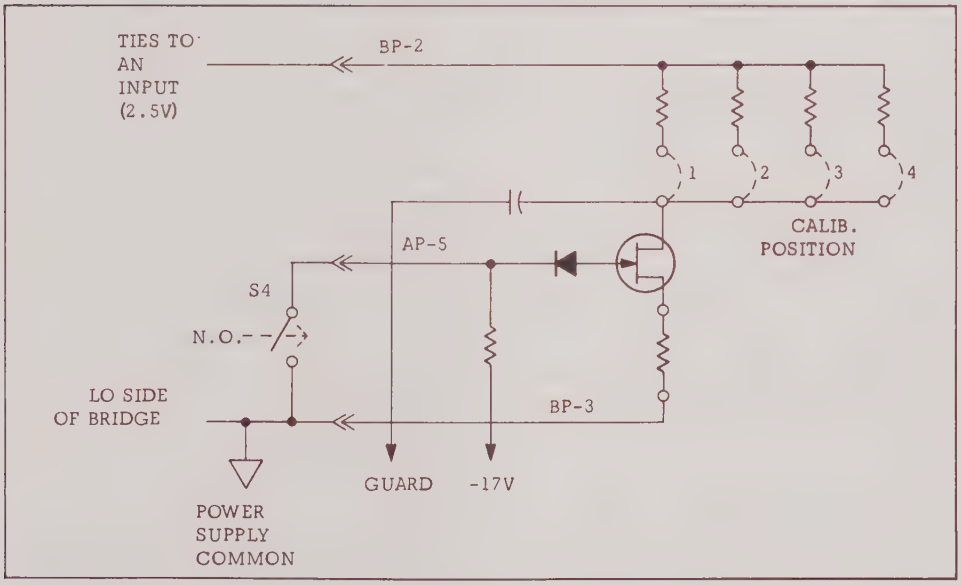



Figure 4.r - F.E.T. Calibration Circuit

## 4.5 F. E. T. Switch

The F. E. T. switch Q1 is used for calibration purposes in conjunction with a bridge network connected to the input terminals. The circuit is activated by a "Master Calibrate" switch mounted on the model 160 enclosure. When the Master Calibrate switch is closed, the F. E. T. acts as a switch and closes the circuit to the calibration resistor (1 thru 4) which goes to the input bridge. The circuit connects the resistor on the opposite side of the bridge from which the balancing of the bridge is accomplished. The addition of a calibration resistor to the input bridge causes a calibrated offset on the output of the amplifier.

## 4.6 Model 160 Enclosure

The Model 160 Enclosure, hereafter called enclosure, is rack mounted. The enclosure accommodates 160 Model 2550 amplifiers, houses the power supply for the amplifiers and the interior temperature controller circuitry. The front door of the enclosure is opened by a key lock and two quarter-turn captive screws. The front panel covers the front of the enclosure and stops drastic changes in the interior ambient temperature when the door is open. Holes drilled in the front panel allow the zero and gain vernier potentiometers on the amplifier to be adjusted with the potentiometer adjustment tool (Dana part number 453281). The control panel assembly is located at the bottom of the front panel. The three fuses protect the following: AC Amplifier Power Supply, AC Heater Circuit, DC Heater Circuit.

From left to right, the three button lights indicate the temperature mode of the enclosure. The buttoms may be pushed to test the lights. The next button is depressed to energize the master calibration circuits on each amplifier. The last button closes a pair of contacts for external equipment. The two binding posts are used for monitoring the excitation voltage.

The purpose of the enclosure design is to maintain a constant temperature within the interior of the enclosure with exterior changes in temperature. The purpose of controlling the temperature within the enclosure is to minimize all temperature effects on the amplifier such as, zero drift and gain accuracy. The enclosure is designed to maintain a temperature approximately equal to the highest exterior ambient temperature to be encountered. Thus, no cooling is necessary to maintain a constant temperature within the enclosure.

### 4.6.1 Temperature Controller

The temperature controller is composed of a thermistor bridge sensing circuit, a DC Heater proportional control circuit and an AC Heater control circuit. The proportional controller is used to supply a nominal power to maintain a predetermined ambient temperature. Should the ambient temperature change, the proportional circuit compensates to minimize changes in the ambient temperature by varying the amount of power supplied to the DC Heaters.

Since it is desirable to have the amplifiers heated to a nominal temperature in the shortest possible time when the box is initially turned on, a separate warmup heater circuit is provided. This circuit heats the box at a maximum rate of 3°C per minute until the temperature is near the predetermined temperature point. At this point the warmup power drops to zero. During this warmup

period the AC Heater is drawing about 1300 watts and the DC Heater is drawing a maximum power of about 150 watts.

The thermistor for the temperature sensing is located in the upper right of the enclosure. The thermistor is mounted on a card between channels 357 and 362. The main controller circuit is located on the bottom of the enclosure on the right side. The current controlling transistors are mounted to the heat sink. The heat sink is mounted to the bottom plate to help disapate the heat produced by transistors Q4, Q5, and Q6. The bottom plate should be hot in normal use.

Sheet heaters are sandwiched between the card guides. Each sheet heater has two elements within the sheet. One element is used for the DC circuit and the other is used for the AC circuit. Heater elements are also found on the PC Board "B". The sheet heaters receive power via cabling up the right side of the enclosure. The PC Board "B" heaters receive power through the control board connector. Note: Several types of insulating foam are used throughout the enclosure and should not be damaged.

Should some malfunction occur with the bridge circuit, thermal fuses are provided. The thermal fuses will cut the heater power if excessive heat is produced. The voltage from the bridge network is fed into the two potentiometric amplifiers M1 and M2. Refer to drawing 430851 in Section 6 Drawings. M1 is a proportional controller for the DC heaters. The output of M1 is fed into Q3 which biases Q4, Q5 and Q6, and controls the current through the DC heaters. M2 feeds into Q15, Q17 and Q18 which drives relay L1, with the relay closure, SCR CR23 and CR26 conduct causing current to flow in the AC heater. The AC heater circuit is not a proportional circuit. It is either on or off depending on the interior temperature of the enclosure.

### .2 Amplifier Power Supply

The amplifier power supply is a shared type power supply. The circuit is signed around four series regulators and two zener reference supplies. The power supply is protected against overloading or shorting to power supply common. Each supply voltage is current limited to a set value. Each of the six power supply voltages are referenced to the +6.5 volt supply. A basic diagram is shown in figure 4.s. The output of the 6.5 volt supply is adjusted to 6.500 VCD $\pm$ 2 mV. No other calibration is required on the power supply. The +6.5 volt regulator is referenced to a 6.2V zener diode. A potentiometric amplifier with an approximate gain of one is used to drive Q8. The -6.5 volt references the +6.5 volt supply and utilizes an operational amplifier with a gain of one. The operational amplifier drives Q12 to give an output of -6.5 volts. The +17 volt supply is referenced from the +6.5V supply. A potentiometric

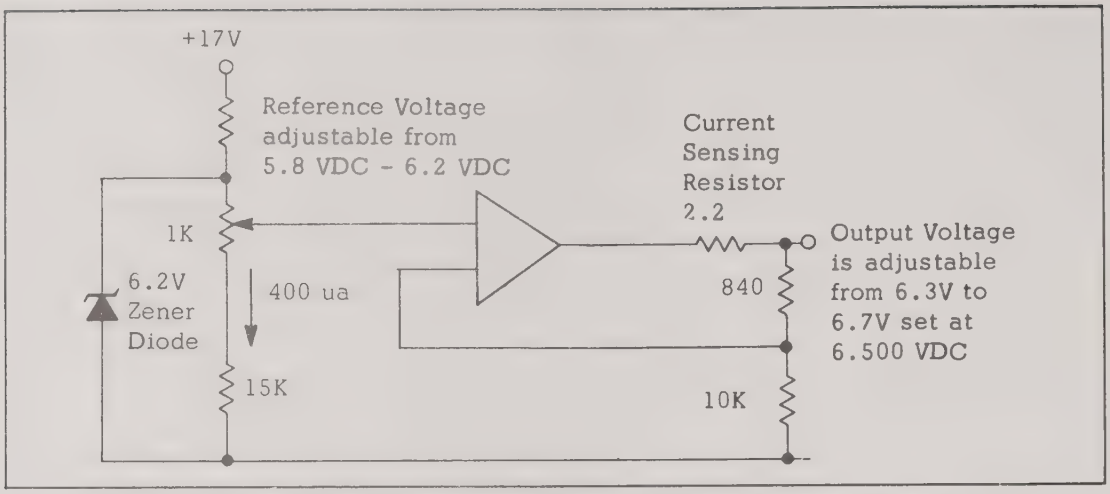



Figure 4.s +6.500 VDC Supply

$$\text{Gain} = \frac{R_1 + R_2}{R_2} = \frac{840 + 10K}{10K} = 1.084$$

amplifier with a gain of approximately 2.6 is utilized to drive Q4 to give an output of +17 volts. Current limiting is provided for the $\pm$17V supplies. The -17 volt supply references the +17V supply output. A gain of one operational amplifier is utilized to drive Q16 for -17 volt output. The +14.9V zener supply is taken off the +17V supply. The -14.9V supply is taken from the -17V supply.

# SECTION 5

# MAINTENANCE

## 5.1 TEST EQUIPMENT

a) OSCILLOSCOPE - Identical X & Y inputs; bandpass, DC-500 kHz; calibrated deflection factors of 1 millivolt to 20 volts per centimeter accurate within 3%; input impedance, 71 megohm paralleled by less than 50 pF. Recommended: Tektronix RM503 or equivalent.

b) OSCILLATOR - Frequency range, 5 Hz - 500 kHz; accuracy, $\pm$ 2% frequency response, $\pm$ 1 dB; adjustable output voltage, 160 milliwatts (10 volts) into 600 ohms rated load, 20 volts open circuit.
Recommended: Hewlett Packard 200 CD or equivalent.

c) AC VACUUM TUBE VOLTMETER - Voltage range, 0.1 millivolt to 300 volts; dB range, -72 to +52 dB; frequency range, 10 Hz to 1 MHz accurate within $\pm$ 2% (50 Hz - 500 kHz); input impedance, 10 Megohms parallel by less than 50 pF.
Recommended: Hewlett Packard 400L or equivalent.

d) DANA MODEL 2195 TEST PANEL - The Dana Model 2195 Amplifier Test Panel provides a convenient means of testing and calibrating Dana amplifiers. The panel requires that only the amplifier input, output and power inputs be connected with no further reconnections required. All input and output configurations necessary to calibrate or test the amplifier are set up by switches and controls mounted on the panel. The panel is shown in Figure 5.a. A special adapter cable for 2550 amplifier to 2195 panel is required.

e) PRECISION VOLTAGE DIVIDER - Standard Decade transformer $10^{-5}$; Electro Scientific Industries (ESI) Dekatran Model DT72A or equivalent.

f) RATIOMETER - AC to AC ratio, 1.0 mV resolution, external reference input, DC range 10 mV to 100V. AC range 1V to 1000V RMS. Ohms range 1.00000 Kohms to 10999.9 Kohms.
Recommended: Dana 5743 DVM.

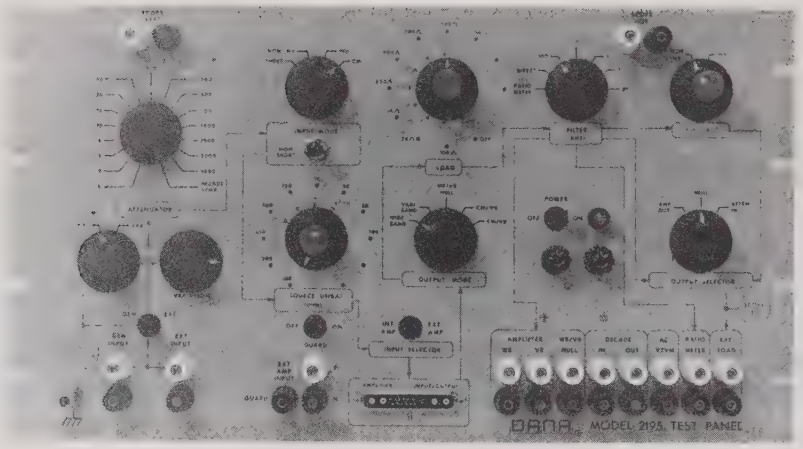



Figure 5.a - Model 2195 Test Panel

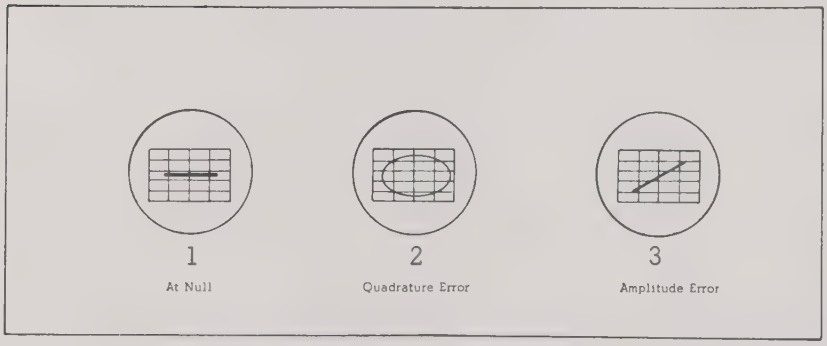



Figure 5.b - Common Mode Lissajous Figures

## 5.2 LISSAJOUS FIGURES IN TESTING THE 2550 AMPLIFIER

Lissajous figures are used throughout the testing of the amplifier. Testing of the amplifier with the use of the 2195 test panel is the fastest way of testing or performing maintenance on the amplifier. Lissajous figures are used in almost every test performed with the 2195 test panel. The same signals appear on both the vertical (Y axis) and the horizontal (X axis) on the oscilloscope. The same signal on both oscilloscope inputs allows a visual representation of any distortions or oscillations which are caused by the amplifier. The audio generator output signal is connected to the X axis and compared to the amplifier output signal on the Y axis of the oscilloscope. The common mode is adjusted by nulling the output voltage as shown in figure 5.b. Figure 5.b.1 shows the amplifier output at Null for maximum common mode rejection.

## 5.3 CALIBRATION PROCEDURES

In addition to the following calibration procedures, certain performance characteristics should be checked periodically and internal adjustments made as required. These measurements are described in Section 5.4. The procedure below should be performed in the order listed.

> Note: All final adjustments and tests for the 2550 amplifier are taken at an ambient temperature of 50°C with the 2550 amplifier installed in the model 160 enclosure. If any minor adjustments are required, the final adjustment must be made after a 30 minute stablization period in the 160 enclosure. Potentiometers R45, R20, R22, and R38 have "locktite" placed on the screw adjustments. "Locktite" must be replaced after adjustment is completed.

a) Turn on all the equipment in 2550 amplifier test set up, except the 2195 test panel. The 2195 test panel includes the power supply for the 2550 amplifier and should not be turned on until the amplifier is plugged in.

b) Adjust the oscilloscope for 5v/cm vertical sensitivity and DC response. Center the trace on the screen. Adjust the horizontal channel to plus external input, 5v/cm sensitivity, and DC response.

c) Connect the "SCOPE VERT" from the 2195 test panel into the vertical input of the oscilloscope. Connect the "SCOPE HOR" from the horizontal input of the oscilloscope.

d) Connect the precision voltage divider as follows: the input of the precision voltage divider to the "DECADE IN" terminals on the 2195 test panel. The output of the precision voltage divider to the "DECADE OUT" terminals on the 2195 test panel. Set the voltage divider to the reciprocal of the gain of 1000, which is .0010000.

e) Connect the audio oscillator to the "GEN INPUT" terminals on the 2195 test panel.

f) Connect the AC VTVM to the vertical input terminals of the oscilloscope.

g) Adjust the 2195 test panel such that:

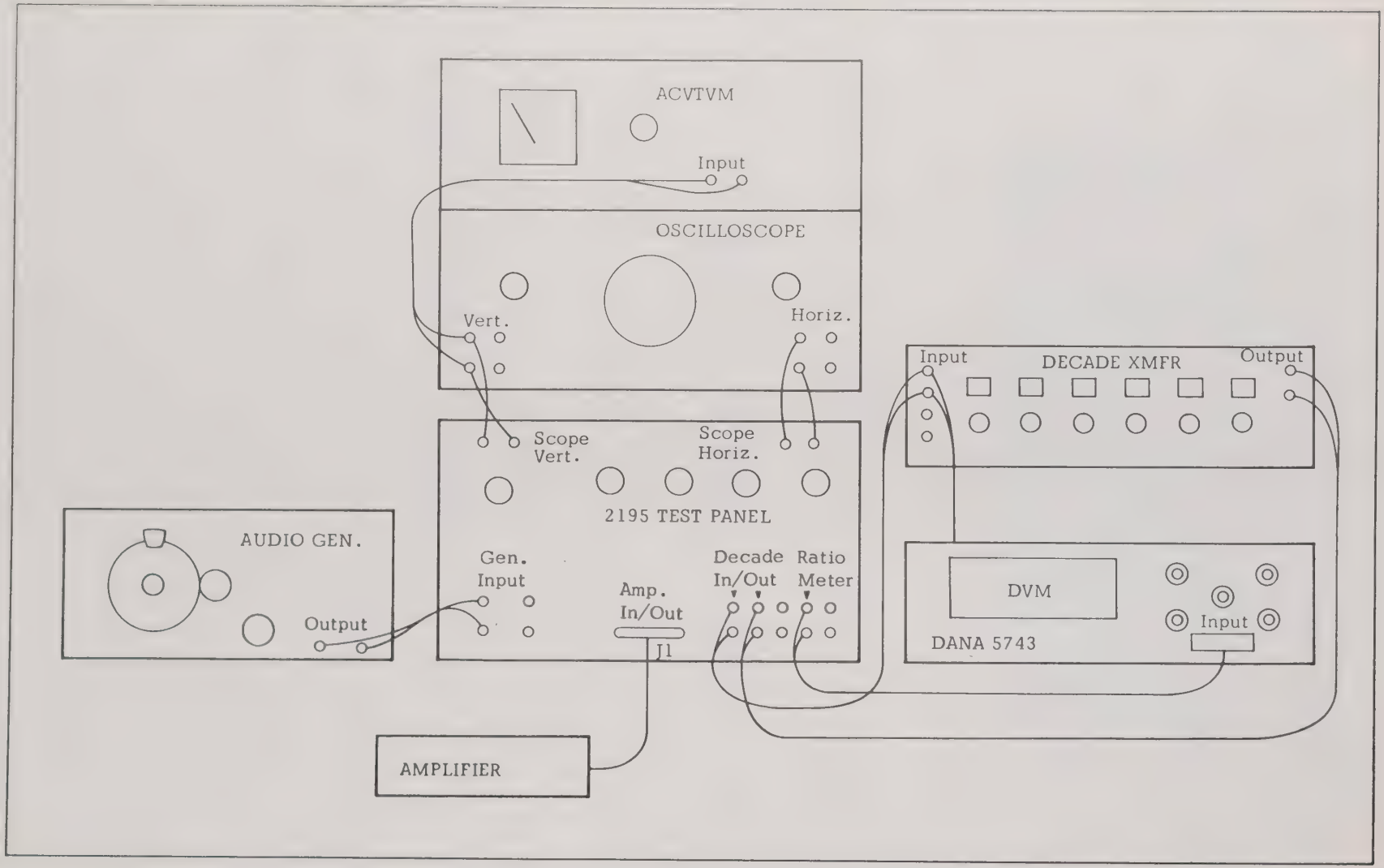



Figure 5.c 2195 Test Panel Setup

1. The "GEN EXT" switch is in the "GEN INPUT" position.

2. The "ATTENUATOR" switch is set to 1000.

3. The "FIX/VAR" switch is set to "FIX".

4. The "INPUT MODE" switch is set to "SHORT".

5. The "SOURCE UNBAL" switch is set such that the red knob is in the "SHORT" position and the black knob is in the 1K position.

6. The "GUARD OFF ON" switch is set to the "ON" position.

7. The "INPUT SELECTOR" switch is set to "INT AMP".

8. The "LOAD" switch is set such that the capacitive load (red knob) and the resistive load (black knob) are both set to "OFF".

9. The "OUTPUT MODE" switch is set to "WIDEBAND" position.

10. The "FILTER KHZ" switch is set to "1".

11. The "NULL ADJ" is set such that the black knob is in the "NON INV" position.

12. The "OUTPUT SELECTOR" switch is set to "ATTEN IN".

h) Adjust the AC VTVM to the +20db range.

i) Adjust the audio generator to a frequency of 60Hz with an amplitude of +19dB as indicated on the AC VTVM. The output voltage will appear as a 20v PP horizontal and vertical deflection on the oscilloscope. The trace will be a diagonal line extending from the first quadrant to the third quadrant of the oscilloscope.

j) Adjust the "OUTPUT SELECTOR" knob on the 2195 test panel to the "AMP OUT" position.

Note: If any soldering is done on the 2550 amplifier, caution must be taken not to burn the humiseal by over heating the terminal. If the humiseal becomes discolored, remove the old humiseal and replace with new humiseal. When changing the jumpers on the amplifier, care must be taken not to move the bifurcated terminals while the solder is still warm. A cold solder joint can result on the circuit side of the printed circuit board.

k) Unsolder and remove the gain jumper. Place a short clip lead in gain position #6. Verify that the jumpers TPA and TPB are in positions # 1 for X1 multiplier. The amplifier is now set to a gain of 1000.

l) Remove the jumper at TPC. ( CAUTION: BEFORE PERFORMING THE NEXT STEPS, BE SURE THAT THE POWER SWITCH ON THE 2195 TEST PANEL IS TURNED OFF).

m) Connect the 2550 adaptor cable to the rear of the 2550 amplifier. Connect the 2550 adaptor cable to the 2195 test panel.

n) Place the "POWER ON" switch on the 2195 test panel in the "ON" position.

5.3.1 Common Mode Adjustment

The amplifier has two controls that effect mode rejection by adjusting the symmetry of the input circuit. R45 compensates for resistive unbalance and C11 adjusts the capacitive symmetry. The location of R45 and C11 is shown on drawing 403085, of Section 6.

a) Place the "INPUT MODE" switch on the 2195 test panel in the "CM" position.

b) Verify that the pattern on the oscilloscope is a straight horizontal line. If the line is tilted, adjust RT1 common mode amplitude error potentiometer (R45). If the pattern is an ellipse, adjust the RTI common mode quadrature trimmer capacitor (C11). Refer to figure 5.b for reference.

c) Common mode rejection may be computed with the following formula.

$$\text{CMR in dB} = 20 \times \text{Log} \frac{20 \text{ volts} \times (\text{K}) \text{ Gain}}{\text{Output Voltage (PP)}}$$

d) Remove the jumpers at TPA and TPB. Place a clip lead at TPA and TPB, position #2. The amplifier is set to a gain of 10.

e) Verify that the pattern on the oscilloscope is similar to figure 5.2c. The amplitude should not be more than 50mV PP. If the amplitude is greater than 50mV PP, follow step 5.3.1f.

f) Replace R-16 with a resistance substitution box. Adjust the value (approximate resistance range 2-50 meg) to the nearest 5% 1/4W carbon resistor value that reduces the amplitude of the display to less than 50mV PP. R16 may be placed in position A or B to achieve the minimum output amplitude. R16 has the same effect as R45 in the K=1000 common mode adjustment.

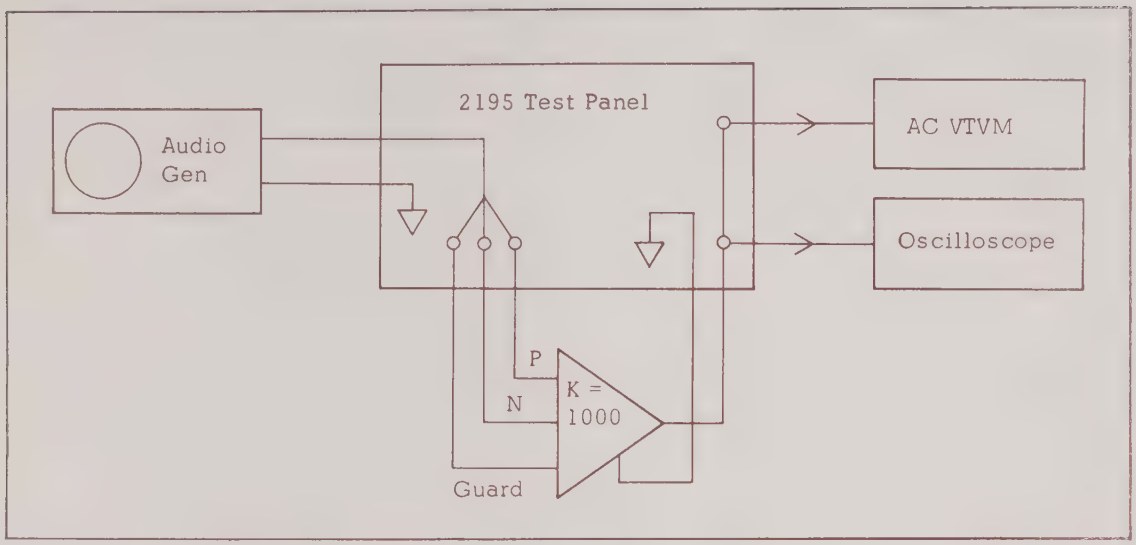



Figure 5.d Common Mode Test with the 2195 Test Panel

5. 3. 2 Collector Zero Adjustment

In addition to the operational ZERO adjustment on the front panel, the amplifier is equipped with a internal zero adjustment (R38).

a) Place the clip leads at TPA and TPB in position #1. The amplifiers gain is now 1000.

b) Adjust potentiometer R38 for zero output. Note any offset.

c) Remove the clip lead in gain position #6 for a gain of 16.

d) Adjust the RTO zero potentiometer for the same output as noted in step 5. 3. 2b.

e) Repeat steps a, b, c and d until the output remains the same on both the highest and lowest gain positions.

f) Place the clip leads at TPA and TPB in position #2. K=10

g) Note the vertical offset from zero, if any, of the pattern on the oscilloscope screen and its polarity.

h) If the offset noted in step 5. 3. 2g above is positive, adjust P source potentiometer R20 to zero or to the same offset as in step 5. 3. 2b.

i) If the offset noted in step g above is negative, adjust N source potentiometer R22 to zero or to the same offset as in step 5. 3. 2b.

5. 3. 3 Input Offset Current Adjustment

This adjustment minimizes current flow through the input terminals. For most accurate adjustment, the following procedures should be performed after the Collector Zero adjustment.

a) Set amplifier GAIN switch to maximum gain position of 1000 (position #6) Note the zero offset if any.

b) Place the red knob of the "SOURCE UNBAL" to the "P" position.

c) Adjust the P source potentiometer R20 to the same offset as in step 5. 3. 3a

d) Place the red knob of the "SOURCE UNBAL" to the "N" position.

e) Adjust the N source potentiometer R22 to the same offset as in step 5. 3. 3a

f) Repeat the above steps until the short P and N positions are at zero.

5. 3. 4 Output Zero Adjustment

This adjustment sets the zero of the Output Amplifier by means of the ZERO adjustment on the front panel.

a) Place the "SOURCE UNBAL" switch on the 2195 test panel in the short position.

b) Place the amplifier in a gain of 16.

c) Adjust the RTO zero potentiometer R73 for zero output. Note any offset.

d) Place the amplifier in a gain of 1000. Install a clip lead in gain position #6

e) Adjust the RTI collector potentiometer R38 for the same offset as noted in step 5. 3. 4d.

f) Place the clip leads at TPA and TPB in position #2 K=10

g) Note the minor vertical offset from zero, on the oscilloscope and the polarity.

h) If the offset noted in step 5. 3. 4g is positive, adjust the P source potentiometer R20 to the same offset as in step 5. 3. 4g.

i) If the offset noted in step 5. 3. 4g is negative, adjust the N source potentiometer R22 to the same offset as in step 5. 3. 4g.

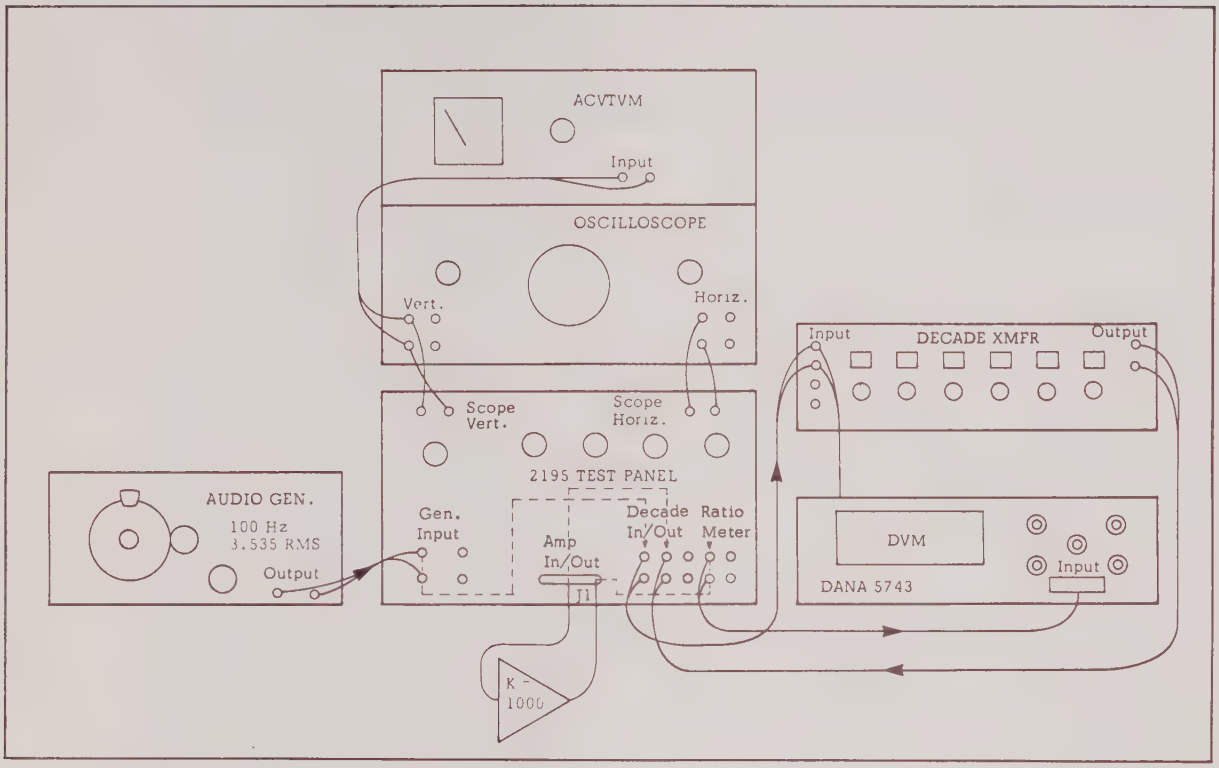



Figure 5.e - Block Diagram of the Test Panel Setup for Gain Tests

## 5.4 TESTS OF AMPLIFIER CHARACTERISTICS

The following measurements check basic amplifier operating characteristics such as gain, bandpass, etc.

### 5.4.1 AC Gain Measurement

a) Place the "ATTENUATOR" in "DECADE XFMR" position.

b) Place TPA and TPB in position #1.

c) Place the "INPUT MODE" switch in the "NON INV" position.

d) Adjust the audio generator to 100Hz and output of 3.535V RMS.

e) Place the "FILTER KHZ" switch in the "RATIOMETER" position.

f) Connect the ratiometer input to the "DECADE OUT" terminals. Connect the AC ratio reference input to the "DECADE IN" terminals. Refer to figure 5.e.

g) Adjust the ratiometer for AC measurement. Place the "REF" control to "INTERNAL".

h) Set the DECADE XFMR to 1.000000. Verify that the output of the DECADE XFMR is 3.535V RMS.

i) Set the reference control to X10 AC external on the ratiometer.

j) Adjust the signal range to 10V input sensitivity on the ratiometer. The ratiometer is in unity, I.E. The same voltage is present on the input and is equal to the reference voltage. This reading is for reference only. Note the reading on the ratiometer.

k) Connect the ratiometer input to the ratiometer terminals on the 2195 test panel.

l) Set the DECADE XFMR to $10^{-3}$ or .0010000.

m) Verify that the amplifier is in a gain of a 1000. Adjust gain vernier potentiometer R-76 to the ccw stop.

n) The reading on the ratiometer should read ± 10 digits of the reading noted in step 5.4.1j.

o) The remaining gains 400 thru 1 may be checked in the same manner.

| Amplifier gain setting | Decade transformer setting | Ratiometer reading |
|---|---|---|
| 1000 | .0010000 | |
| 400 | .0020000 | |
| 200 | .0050000 | |
| 100 | .0100000 | |
| 40 | .0250000 | |
| 16 | .0625000 | ± 10 digits of step |
| 10 | .1000000 | 5.4.1 j |
| 4 | .2500000 | |
| 2 | .5000000 | |
| 1 | 1.0000000 | |

5.4.2 Linearity Measurements

Ideally, gain should be independent of the magnitude of the output voltage from minus full scale to plus full scale. Since the Dana Amplifier's departure from this idea is small, the null balance method of the gain measurement is again used.

a) Place the "ATTENUATOR" on the 2195 test panel in the "1000" position.

b) Place the "FILTER KHZ" switch in the "1" position.

c) Place the "OUTPUT SELECTOR" in the "NULL" position.

d) Place the amplifier in a gain of 1000.

e) Adjust the "FIX VAR" control until the line on the oscilloscope assumes an elliptical circle on the X axis. Adjust the X axis amplifier if necessary to see the trace on the oscilloscope.

f) Place the black knob of the "NULL ADJ" in the "NON INV" position. Adjust the red knob to flatten or close the elliptical circle to a straight line along the X axis.

g) Repeat step e and f to obtain the flattest possible trace. Superimpose a straight line over the trace on the oscilloscope. The PP difference is the null reading. The linearity in percentage can be calculated as follows:

$$\text{Linearity } \% = \frac{\text{Peak null detector reading (volts) X100}}{\text{full scale (10 volt)}}$$

5.4.3 Bandwidth Measurement

Bandwidth is measured by determining the difference in AC gain at low

and at high frequencies. Since there is seldom a need to define bandwidth with extreme accuracy, the measurement procedures may be shortened as follows:

a) Place the "FIX VAR" switch in the "FIX" position.

b) Place the "FILTER KHZ" switch in the "DIRECT" position.

c) Place the black knob of the "NULL ADJ" in the "AMP OUT" position.

d) Adjust the audio generator to 60Hz and a amplitude of 3.535 VRMS.

e) Set the X and Y axis of the oscilloscope to 2v/cm.

f) Verify that there is a straight line going from the third quadrant to the first quadrant, with an amplitude of + 13.2dB.

g) Place the "INPUT MODE" switch to the "INV" position.

h) Verify that there is a straight line going from the fourth quadrant to the second quadrant, with an amplitude of + 13.2dB.

i) Adjust the audio generator to 2kHz and a amplitude of 3.535V RMS.

j) Repeat step h. Verify that the output is +13.2 dB ± 3dB.

k) Place the "INPUT MODE" switch to the "NON INV" position.

l) Repeat step f. Verify the output is +13.2 dB ± 2dB.

5.4.4 Variband Measurement

The variband is connected into the circuit by installing the jumper at TPC. The amplifier is shipped with the variband fco frequency of 150 Hz, 50 Hz, or 20 Hz.

a) Connect a clip lead at TPC.

b) Adjust the frequency of the audio generator to the variband fco frequency with an amplitude of 13.2 dB.

c) Verify that the output of the amplifier is 10.2 dB ± 2dB

5.4.5 Output Limiting

a) Adjust the oscilloscope X and Y axis senstivity to 5v/cm.

b) Remove the clip lead at TPC.

c) Adjust the audio generator to 60Hz. Increase the amplitude of the audio generator until the output is clipped in the positive direction + 6 V peak ± .5V.

d) Continue to increase the audio generator amplitude until the oscilloscope indicates the output is clipped in the negative direction -10.5V peak ±.5V.

5.4.6 FET Calibration Circuit

a) Adjust the DVM to;

1. FUNCTION switch to KILOHMS.

2. SIGNAL RANGE to AUTO.

3. REFERENCE CONTROL to INTERNAL.

b) Connect the DVM + SENSE and + CURRENT lead to the CALIB "A" wire from the adapter cable.

c) Connect the DVM - sense and - current lead to the CALIB "B" wire.

d) Install a jumper in the CALIB POSITION #4.

e) Verify that the DVM OHM METER reads open.

f) Connect the MASTER CALIBRATE lead from the adapter cable to the CALIB "B" lead.

g) Verify that the DVM OHM METER reads 25.000K ohm ± .012 K ohm.

h) Remove the MASTER CALIBRATE lead from the CALIB "B" lead. Verify that the DVM OHM METER reads open.

i) Calibration positions 1, 2 and 3 can be checked in the same procedure as above. Move the jumper from "CALIB POSITION 4" to 3, 2 and 1 for each check.

The following resistances should be noted:

| | | |
|---|---|---|
| Calib position | #1 | 250.000 Kohm ± .120 Kohm |
| | #2 | 100.000 Kohm ± .050 Kohm |
| | #3 | 50.000 Kohm ± .025 Kohm |
| | #4 | 25.000 Kohm ± .012 Kohm |

## 5.5 ENCLOSURE TEMPERATURE CONTROLLER CALIBRATION

The temperature controller within the enclosure controls the amount of power going to the DC and AC heater elements. The lamps mounted on the enclosure control panel indicate the interior temperature. The amber lamp indicates that the enclosure temperature is below the set point. The set point is the temperature point at which the enclosure is to stabilize. The green lamp indicates that the temperature has reached the range of normal operation, and red lamp indicates that the temperature of the interior of the enclosure is above the set point and not in a stable condition. The sequence of operation of the controller is controlled by the thermistor in the bridge circuit.

The enclosure is initially turned on. The thermistor is at maximum resistance of about 10 Kohms. The control circuit calls for maximum heating. The AC Heater circuit or warm-up power is at maximum unless the interior enclosure temperature is at or above the set point. The DC Heater circuit calls for maximum power until the set point is reached. The amber lamp will indicate that both heaters are heating. Close to the set point, the amber lamp will go out and the green lamp will lite. At about 33°C the AC Heater circuit will cut off. The DC heater will supply any remaining heating and will stabilize the enclosure at the set point of 50°C.

### 5.5.1 Bottom Enclosure Panel Disassembly

Remove the fifteen screws holding the front panel in place. Remove the front panel. Lay the enclosure on the right side. Remove the thirteen screws on the top bottom and back edges of the bottom panel assembly. Remove the four screws in a straight line. They are located in the center of the bottom panel in a straight line from the front of the enclosure to the back of the enclosure. Slide the bottom panel toward the front of the enclosure to disconnect the two edge connectors from the back panel. Pull the top edge of the bottom panel away from the enclosure and lay the bottom panel assembly down next to the enclosure.

NOTE: The interconnecting wires from the bottom panel to the enclosure are connected to the terminal block on the side of the enclosure which is lying down. Do not try to remove the bottom panel from this side, as damage to the interconnecting cables could result.

### 5.5.2 Calibration of Temperature Controller

(a) Verify that the power is disconnected to the enclosure.

(b) Disconnect the #1 and #2 wires at the terminal block. Refer to drawing 403104-3.

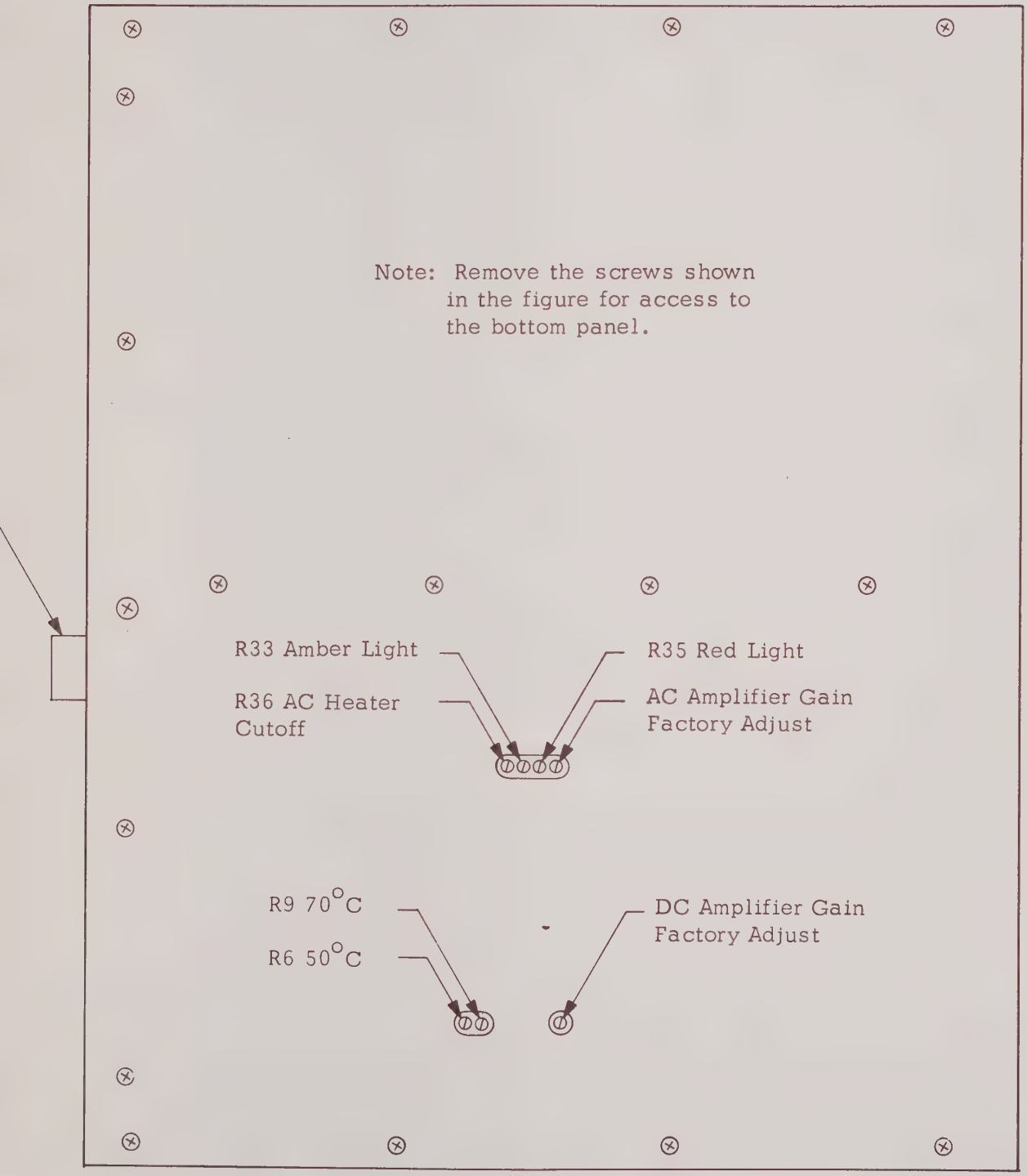

Note: Remove the screws shown in the figure for access to the bottom panel.
R33 Amber Light
R36 AC Heater Cutoff
R35 Red Light
AC Amplifier Gain Factory Adjust
R9 70°C
R6 50°C
DC Amplifier Gain Factory Adjust

Figure 5.f Bottom Panel Temperature Controller Adjustment

| Temperature $^{O}C$ | Multiple |
|---|---|
| $23^{O}C$ | 1.00 |
| 30 | .806 |
| 33 | .710 |
| 35 | .653 |
| 40 | .533 |
| 45 | .437 |
| 50 | .360 |
| 60 | .249 |
| 65 | .208 |
| 70 | .175 |
| 75 | .148 |
| 80 | .126 |

Figure 5.g - Conversion Table

$R_{th}$ = Thermistor resistance at $25^{O}C$

$R_{th}'$ = Resistance multiple factor from chart at some temperature in $^{O}C$

Example:

$R_{th}$ = 10 Kohms at $25^{O}C$

Rth' = unknown ohm at $50^{O}C$

10 Kohms x .360 = 3.6 Kohms at $50^{O}C$

(c) Measure the resistance between terminal block terminals #1 and #2. The resistance should measure about 10 Kohms, provided the ambient temperature in the enclosure is about 25°C. Note the thermistor's resistance at 25°C. Scale proportionately if the thermistor is higher or lower in resistance. Refer to Table 5.g.

(d) Remove the 15 ampere AC Heater circuit fuse F2.

(e) Connect a decade resistance box to terminal block terminals #1 and #2. Adjust the decade resistance box to 10 Kohms or the same value noted in step 5.5.2.c.

(f) Apply power to the enclosure. Connect a 10 ampere current meter in series with the 28V source. Connect a 15 ampere AC current meter in series with the AC source.

(g) The amber lamp should light. Remove the connection to #1 terminal on the terminal block. Verify that the amber lamp goes out and the red lamp lights. Reconnect the decade resistance box. Verify that the red light remains on.

(h) Calculate the value of the thermistor at 45°C. Use the following formula:

$R_{th}$ (noted in step 5.5.2.c) · $R_{th}$ at 45°C (refer to table 5.g) = $R_{th}$ at 45°C. Approximately 4.37K $R_{th}$ at 45°C is the set point. Adjust the decade resistance box to this value.

(i) Adjust the 50°C set point potentiometer R6 such that 3.0 amperes is drawn from the 28 VDC supply. Refer to figure 5.f.

(j) Adjust the decade resistance box to 10 Kohms. The amber lamp should be lit.

(k) Calculate $R_{th}$ at 40°C. Approximately 5.33 Kohms. Adjust the decade resistance box to the value found in $R_{th}$ at 40°C.

(l) Adjust the amber to green potentiometer R33 for the amber to green transition point.

(m) Calculate $R_{th}$ at 70°C. Approximately 1.75 Kohms. Adjust the decade resistance box to the value found $R_{th}$ at 70°C.

(n) Adjust the green to red potentiometer R35 for the green to red transition point.

(o) Calculate $R_{th}$ at 33°C. Approximately 7.1 Kohms. Adjust the decade resistance box to 10 Kohms.

(p) Disconnect the AC power. Insert the 15 ampere AC Heater fuse. Apply power to the enclosure.

(q) Note the AC current meter. If the meter indicates 11 amperes, the warm-up heaters are on. If the current meter indicates 1 ampere, the warm-up power is off.

(r) Adjust the decade resistance box from 10 Kohms to a lesser value than in step 5.5.2.o. Note the value at the decade resistance box when the AC current drops from 11 amperes to 1 ampere. Adjust the relay cutoff potentiometer R36 for a cutoff point at the value determined in step 5.5.2.o. Approximately 7.1 Kohms. Always start at 10 Kohms and decrease the resistance value on the decade box. Repeat until the cutoff point is at the 33°C set point.

The relay turn on point and turn off points do not occur at the same time due to relay Hysteresis.

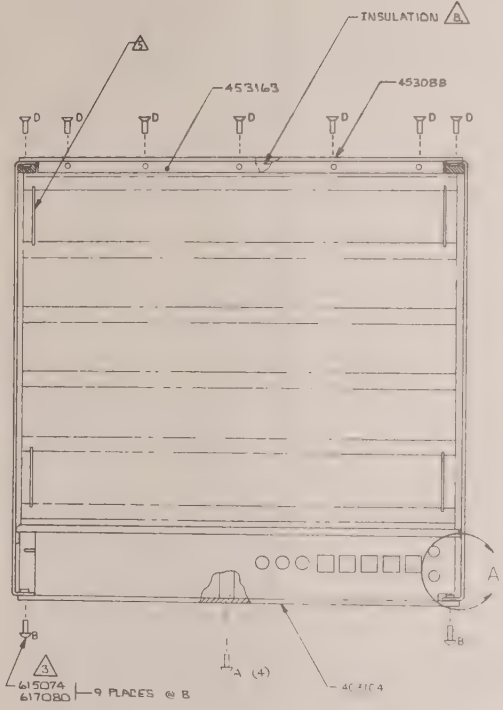
NOTE: Monitor AC current since the 11 ampere current indicates full warm-up power of 1300 watts is on. Do not leave warm-up power on without thermistor and enclosure completely assembled for greater than 15 minutes continuously.

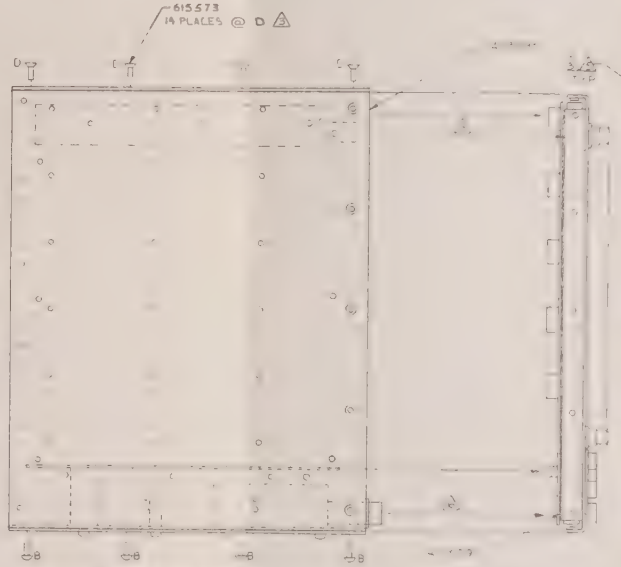
## SECTION 6

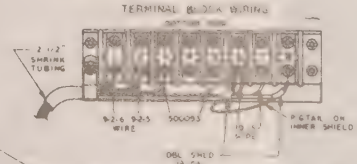
## DRAWINGS

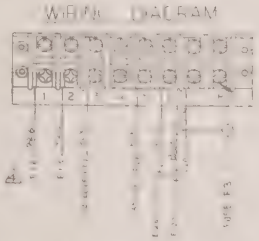
| | |
|---|---|
| Signal Conditioning Subsystem - Dimensional Outline | 453060-1 |
| Enclosure Assembly 160A | 403090-1 |
| Enclosure Assembly 160B | 403235-1 |
| Bottom Panel Assembly - 160 Enclosure - Cable Routing Detail | 403104-2 |
| Bottom Panel Assembly - 160 Enclosure - Wiring Diagram | 403104-3 |
| Bottom Panel Assembly - 160 Enclosure Bill of Materials | 403104-1 (3 sheets) |
| Card Cage Assembly 160A | 403095-2 |
| Card Cage Assembly 160B | 403238-1 |
| Rear Module Assembly 160A | 403091-1 |
| Rear Module Assembly 160B | 403236-1 |
| Connection Diagram - 160 Rear Module A | 430852 |
| Connection Diagram - 160 Rear Module B | 430853 |
| PCB Assembly, 2550 Amplifier | 403085-1 |
| Schematic, 2550 Amplifier | 430849 |
| Bill of Material, 2550 Amplifier | 403055 (5 sheets) |
| PC Board Assembly - Power Supply | 403105-1 |
| PC Board Assembly - Power Supply | 403105-2 |
| PC Board Assembly - Temperature Control | 403106-1 |
| PC Board Assembly - Temperature Control | 403106-2 |
| PC Board Assembly - Temperature Control | 403106-3 |
| Schematic, Power Supply 160 | 430850-1 |
| Schematic, Control 160 | 430851 |

| REVISIONS | | | | |
|---|---|---|---|---|
| LTR | DESCRIPTION | DR | CHK | APPD |
| A | RELEASED PER DRN # 887 6-4-9 | | | |
| B | REVISED PER EO 5182 | | | |
| C | REVISED PER EO 5308 | | | |
| D | REVISED PER EO 5406 | | | |
| E | DELETE 610407 & NOTE 7, EO 6501 | | | |




SEE SHEET 2 OF 4.

~~INSTALL MOUNTING SCREWS PRIOR TO TIGHTENING OF SCREWS ON BOTTOM PANEL.~~

LOOSEN HEATSINK AND RFI FILTER SCREWS OF BOTTOM PANEL ASSY PRIOR TO ALIGNMENT WITH REAR MODULE ASSY.

LOOSEN REAR MODULE ASSY SCREWS PRIOR TO ALIGNMENT WITH CARD CAGE ASSY USING DUMMY BOARDS AS SHOWN.

'E' NUMBERS AND CABLE DESTINATION ARE LOCATED ON 403104 ASSY.

APPLY LOCTITE, P/N 920328, PER APPLICATION SPECIFICATION 900075 TO ALL LOOSENED AND INDICATED FASTENERS AFTER ALIGNMENT OF REAR MODULE ASSY AND BOTTOM PANEL ASSY ARE COMPLETE.

2. ASSEMBLY METHOD AND SEQUENCE TO FOLLOW PRODUCTION ENGINEERING "OPERATION DETAIL SHEET".

1. ASSEMBLY PROCEDURES AND PROCESSES TO CONFORM WITH DANA WORKMANSHIP STANDARDS.

NOTES: UNLESS OTHERWISE SPECIFIED

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES AND INCLUDE THICKNESS OF PLATING.

TOLERANCES
DEC MAS X.030 XX.020 XXX.010 | ANGLES ± ½° FORMED ± 1° | HOLE DIAMETERS - .004 .001

DIMENSIONS AND TOLERANCES PER USAS Y14.5

MATERIAL: SEE L/M | FINISH

| | | | |
|---|---|---|---|
| DRAWN | [illegible] | 4-29-69 | |
| CHECK | [illegible] | 5-1-69 | |
| DESIGN | J. MONROY | 29 APR 1969 | |
| MECH ENGR | [illegible] | 5-1-69 | |
| PROJ ENGR | [illegible] | 5-5-69 | |
| PROD ENGR | [illegible] | 5/6/69 | |
| Manager | | 5/12/69 | |

| | | | | |
|---|---|---|---|---|
| 400902 | 160A | 1 | 1 | |
| NEXT DWG | USED ON | MFG REQ | FINAL ASSY | |
| APPLICATION | | QTY REQD | | |

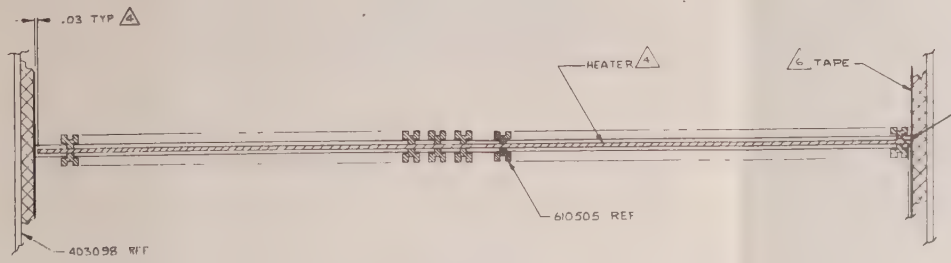
DANA DANA LABORATORIES INC. IRVINE, CALIFORNIA

ENCLOSURE ASSEMBLY-160 A

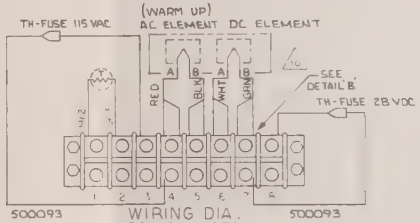
| SIZE | CODE IDENT NO. | DWG NO. | REV |
|---|---|---|---|
| D | 21793 | 403090 | E |

SCALE 1/2 SHEET 1 OF 4

| REVISIONS | | | | |
|---|---|---|---|---|
| LTR | DESCRIPTION | DR | CHK | APPD |
| | RELEASED PER DRN # SEE SHEET 1 | | | |

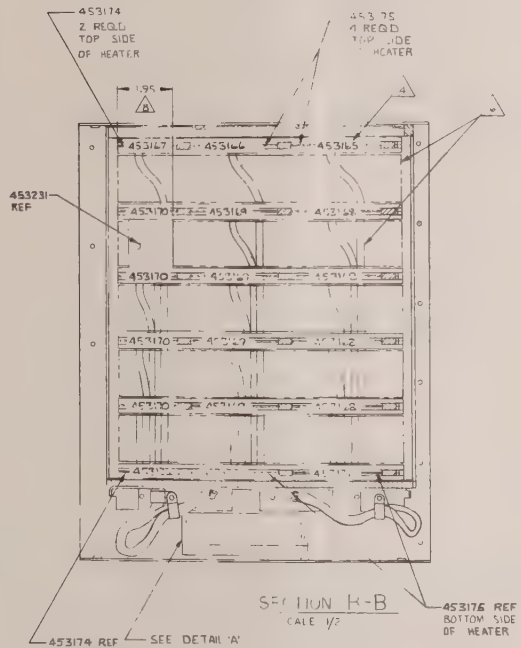



SECTION A-A
SCALE 1/1

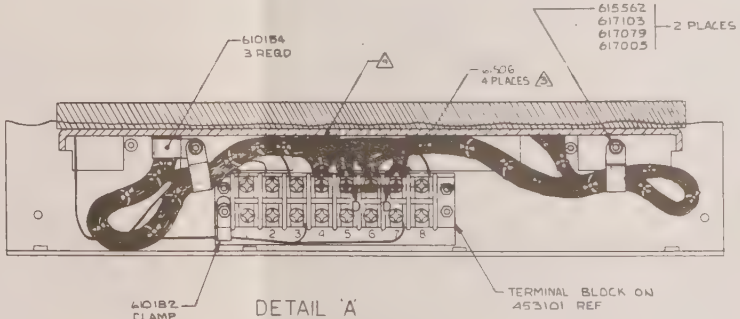



WIRING DIA.

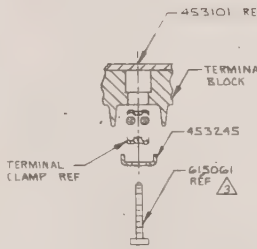
DETAIL B


453174 2 REQ'D TOP SIDE OF HEATER
453175 4 REQ'D TOP SIDE OF HEATER
453231 REF
453174 REF BOTTOM SIDE OF HEATER
SEE DETAIL 'A'
453176 REF BOTTOM SIDE OF HEATER

SECTION B-B
SCALE 1/1




DETAIL 'A'
SCALE 1/1




SECTION D-D
SCALE : 2/1
TYP 4 PLACES

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 403090 | 160A | 1 | 1 | | | | |
| NEXT DWG | USED ON | REQ'T DWG | FINAL ASSY | UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES AND INCLUDE THICKNESS OF PLATING | | | |
| APPLICATION | | QTY REQD | | TOLERANCES: DECIMALS X.030, XX.020, XXX.010; ANGLES 0.30' FORMED 1°0'; HOLE DIAMETERS +.004 -.001 | | | |
| | | | | DIMENSIONS AND TOLERANCES PER USAS Y14.15 | | | |
| | | | | MATERIAL: SEE L/M | FINISH | | |

| | | |
|---|---|---|
| DRAWN | RT Wellman | 9-3-69 |
| CHECK | W. Shirley | 9-3-69 |
| DESIGN | J. MONROY | 10 APR 1969 |
| MECH ENGR | | 5-1-9 |
| PROJ ENGR | | 5-7-9 |
| PROD ENGR | | 6/7/69 |
| | Marshall 5/1/9 | |

DANA LABORATORIES INC.
IRVINE CALIFORNIA

CARD CAGE ASSY— 160 A ENCLOSURE

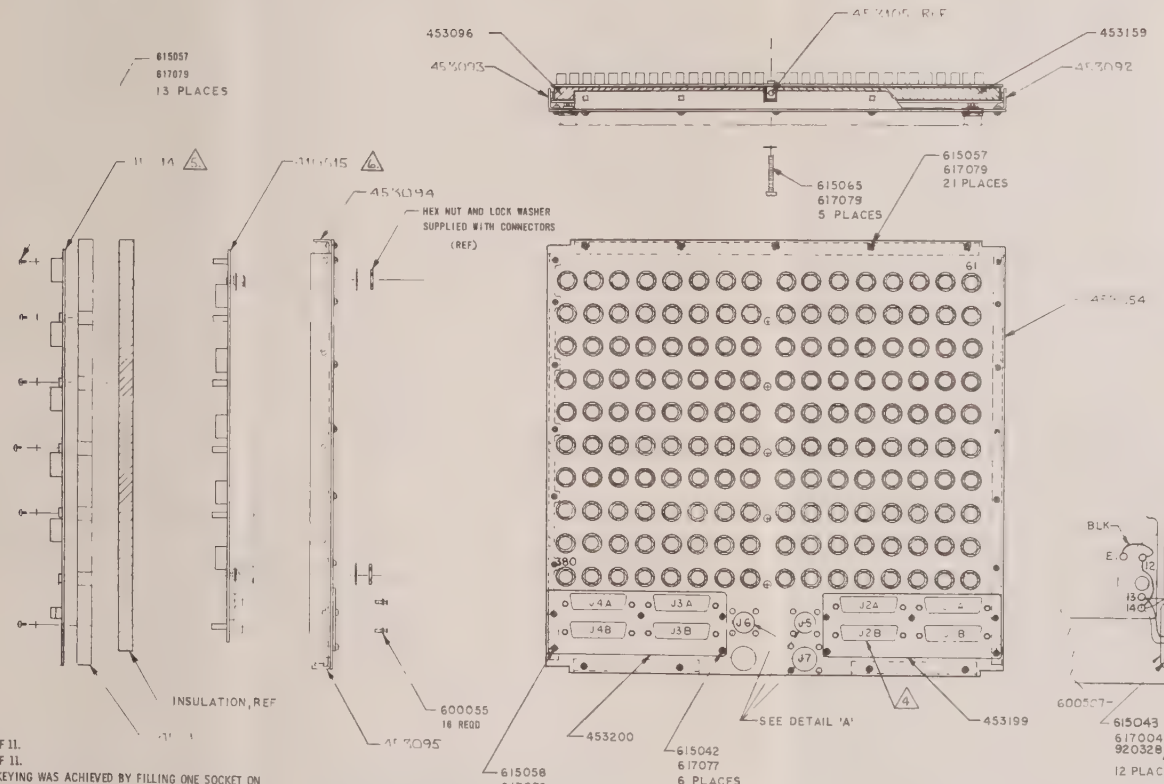
| SIZE | CODE IDENT NO | DWG NO | REV |
|---|---|---|---|
| D | 21793 | 403095 | D |

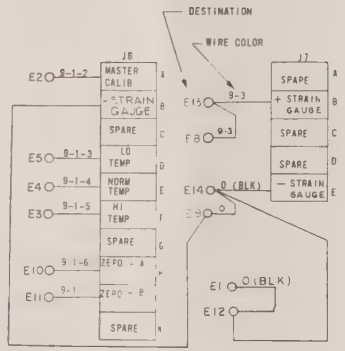
SCALE NOTED | SHEET 2 OF

SEE SHEET 1

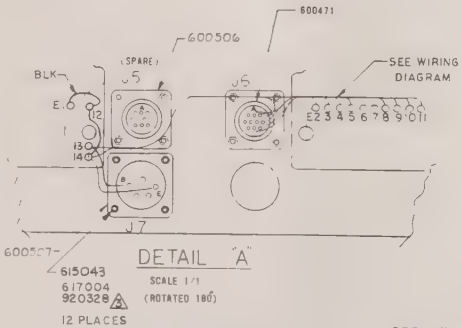
NOTES: UNLESS OTHERWISE SPECIFIED

| REVISIONS | | | | |
|---|---|---|---|---|
| LTR | DESCRIPTION | DR | CHK | APPD |
| A | RELEASED PER DRN # 5[illegible] | [illegible] | | |
| B | ADD 430852 TO B/M PER EO 5002 | [illegible] | | |
| C | REVISE PER E.O. 5183 | [illegible] | | |
| D | REVISED PER EO 5309 | [illegible] | | |
| E | REVISED PER EO 5409 | [illegible] | | |




WIRING DIAGRAM




DETAIL "A"
SCALE 1/1
(ROTATED 180°)

REF. CHNL 61-150, 311-380

⚠6 SEE SHEET 3 OF 11.
⚠5 SEE SHEET 2 OF 11.
⚠4 MECHANICAL KEYING WAS ACHIEVED BY FILLING ONE SOCKET ON EACH OUTPUT CONNECTOR WITH SOLDER AS FOLLOWS: J1A & B-SOCKET #23, J2A & B-SOCKET #24, J3A & B-SOCKET #28, J4A & B-SOCKET # 29.
⚠3 APPLY LOCKTITE, P/N 920328 PER APPLICATION SPEC 900075.
2. CONNECTION DIAGRAM FOR COMPLETE REAR MODULE ASSY AND SUB-ASSYS, SEE 430852.
1. ASSY PROCEDURES AND PROCESSES TO CONFORM TO DANA WORKMANSHIP STANDARDS.

NOTES: UNLESS OTHERWISE SPECIFIED

| | | | |
|---|---|---|---|
| 403090 | 160 A | 1 | 1 |
| NEXT DWG | USED ON | NEXT ASSY | FINAL ASSY |
| APPLICATION | | QTY REQD | |

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES AND INCLUDE THICKNESS OF PLATING

TOLERANCES

| DECIMALS | ANGLES | HOLE DIAMETERS |
|---|---|---|
| X .030<br>XX .020<br>XXX .010 | 0° 30' FORMED 1° 0' | + .004<br>- .001 |

DIMENSIONS AND TOLERANCES PER USAS Y14.15

MATERIAL: SEE L/M
FINISH:

| | | |
|---|---|---|
| DRAWN | E. T. Willman | 12-17-63 |
| CHECK | J. Mooney | 12-17-63 |
| DESIGN | [illegible] | 12-17-63 |
| MECH ENGR | | |
| PROJ ENGR | D. MacKay | 5-9-67 |
| PROD ENGR | [illegible] | 6-3-67 |
| | Maynard S. [illegible] | 6/6 |

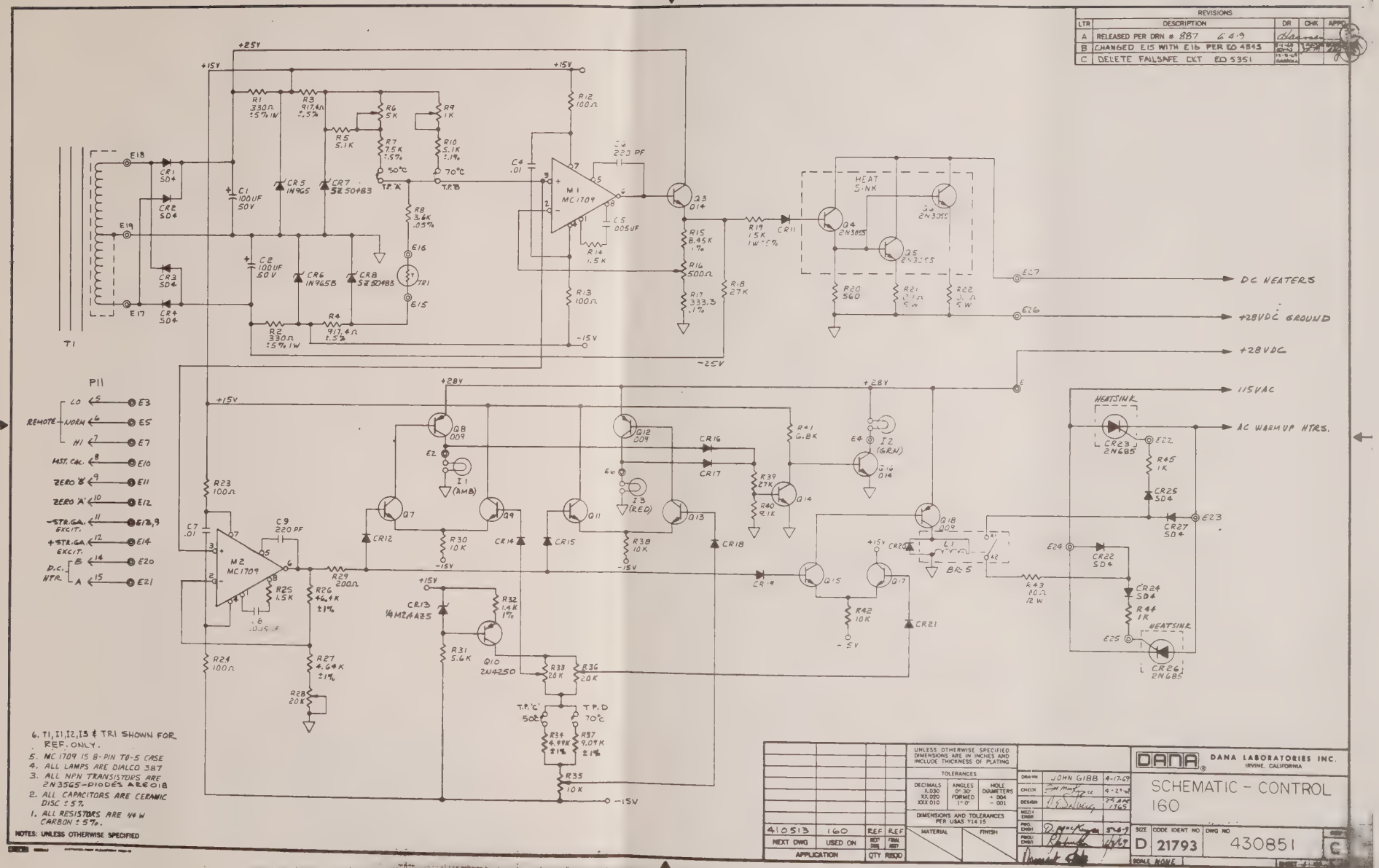
DANA LABORATORIES INC.
IRVINE CALIFORNIA

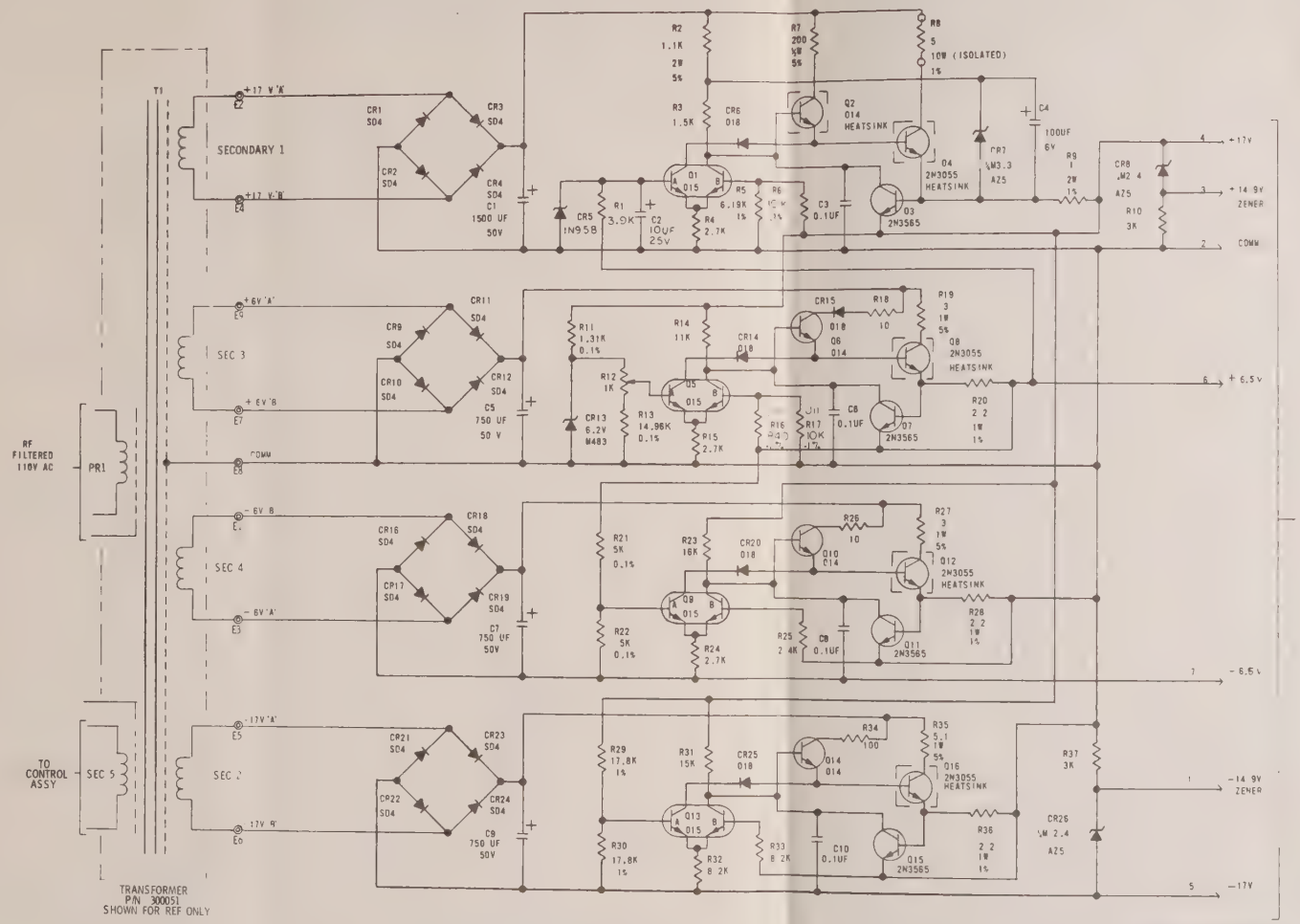
# REAR MODULE ASSY-160 A

| SIZE | CODE IDENT NO | DWG NO | REV |
|---|---|---|---|
| D | 21793 | 403091 | E |

SCALE 1/2 SHEET 1 OF 11

SHEET 9, 10, & 11 ARE "A" SIZE


REVISIONS
LTR | DESCRIPTION | DR | CHK | APPD
A | RELEASED PER DRN # 887 6-4-9
B | CHANGED E15 WITH E16 PER EO 4845
C | DELETE FAILSAFE CKT EO 5351
+25V
+15V
-15V
-25V
+28V
T1
P11
LO
REMOTE WORM
HI
MST. CAL.
ZERO 'B'
ZERO 'A'
-STR.GA. EXCIT.
+STR.GA. EXCIT.
D.C. HTR.
M1 MC1709
M2 MC1709
HEAT SINK
DC HEATERS
+28VDC GROUND
+28VDC
115VAC
AC WARM UP HTRS.
BR-5
TP.'A'
TP.'B'
TP.'C' 50°C
TP.'D' 70°C
6. T1, I1, I2, I3 & TR1 SHOWN FOR REF. ONLY.
5. NC 1709 IS 8-PIN TO-5 CASE
4. ALL LAMPS ARE DIALCO 387
3. ALL NPN TRANSISTORS ARE 2N3565-DIODES ARE 018
2. ALL CAPACITORS ARE CERAMIC DISC ±5%
1. ALL RESISTORS ARE ¼ W CARBON ±5%.
NOTES: UNLESS OTHERWISE SPECIFIED
DANA LABORATORIES INC.
IRVINE, CALIFORNIA
SCHEMATIC - CONTROL 160
SIZE D
CODE IDENT NO 21793
DWG NO 430851
REV C
410513 160
NEXT DWG USED ON
APPLICATION




| REVISIONS | | | | |
|---|---|---|---|---|
| LTR | DESCRIPTION | DR | CHK | APPD |
| A | RELEASED PER DRN # 897 6-4-9 | | | |

3. REFERENCE-SEE CONNECTION DIAGRAM 430852
2. LAST REF. DESIGNATIONS USED R37, CR26, C10, Q16
1. ALL RESISTORS ARE IN OHMS, ½W ±5%
NOTES: UNLESS OTHERWISE SPECIFIED

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES AND INCLUDE THICKNESS OF PLATING

TOLERANCES

| DECIMALS | ANGLES | HOLE DIAMETERS |
|---|---|---|
| X .030 | 0 30' | - .004 |
| XX .020 | FORMED | - .001 |
| XXX .010 | 1° 0' | |

DIMENSIONS AND TOLERANCES PER USAS Y14.15

MATERIAL | FINISH

| | | | |
|---|---|---|---|
| DRAWN | W.E. Sullivan | 4 DEC 1969 | |
| CHECK | I. Burgess | 5 DEC 1969 | |
| DESIGN | W.E. Sullivan | 5 DEC 1969 | |
| MECH ENGR | | | |
| PROJ ENGR | D. Mackenzie | 5-6-69 | |
| PROD ENGR | Kolman | 6-5-69 | |

Released 5/6/69

| | | | |
|---|---|---|---|
| 403105 | 160 | REF | REF |
| NEXT DWG | USED ON | NEXT DWG | FINAL ASSY |
| APPLICATION | | QTY REQD | |

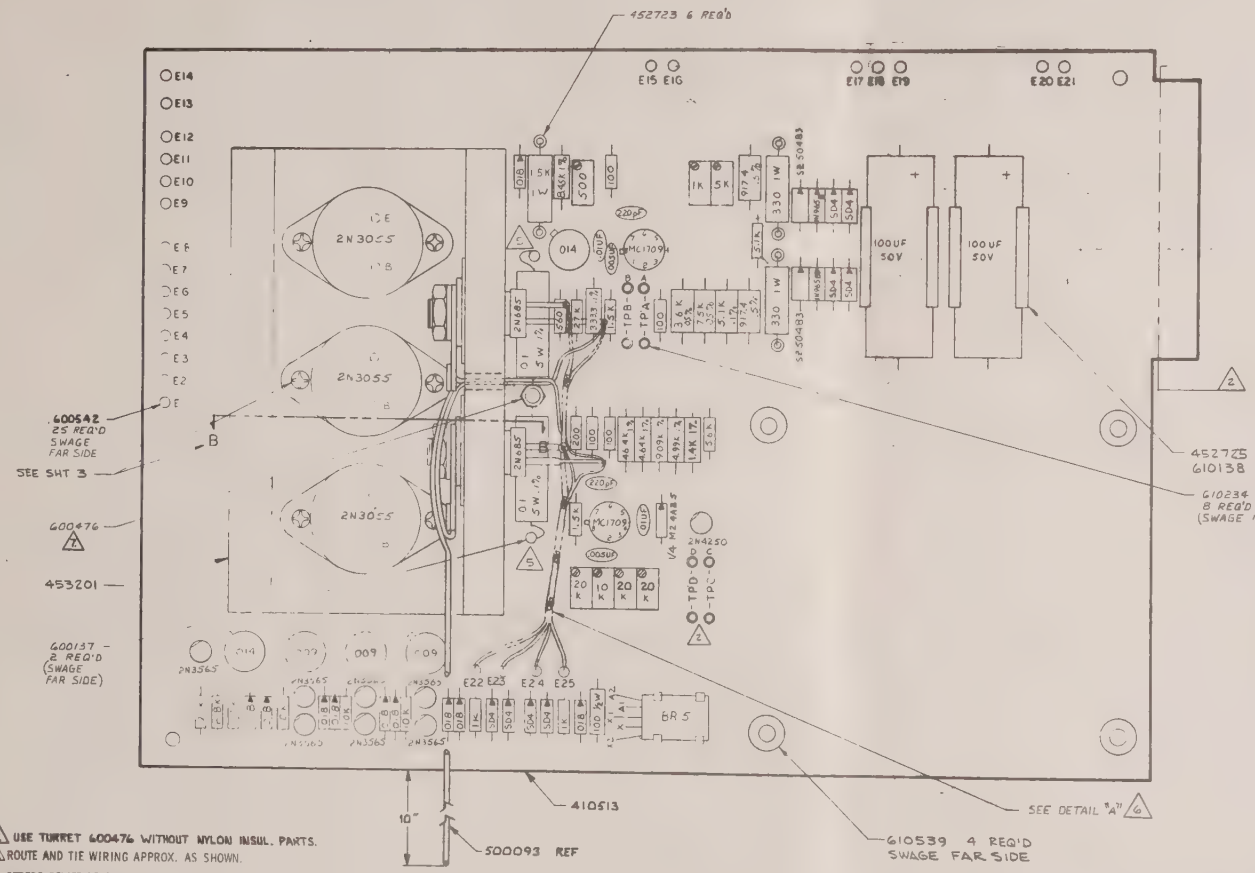
DANA DANA LABORATORIES INC. IRVINE, CALIFORNIA

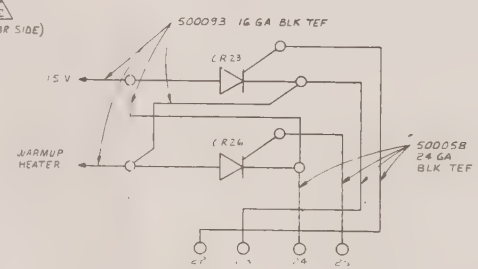
# SCHEMATIC - POWER SUPPLY, 160

| SIZE | CODE IDENT NO | DWG NO | REV |
|---|---|---|---|
| D | 21793 | 430850 | A |

SCALE — SHEET 1 OF 1

| REVISIONS | | | | |
|---|---|---|---|---|
| LTR | DESCRIPTION | DR | CHK | APPD |
| | RELEASED PER DRN # [illegible] SHT 1 | | | |




DETAIL A

WIRING DIAGRAM

7. USE TURRET 600476 WITHOUT NYLON INSUL. PARTS.
6. ROUTE AND TIE WIRING APPROX. AS SHOWN.
5. STRESS RELIEF BEND ON R21 AND R22.
4. REF--LIST OF MATERIAL AND ADDITIONAL ASSY. DETAILS ON SHEET 3.
3. ALL RESISTORS ARE IN OHMS 1/4W ± 5%.
2. MASK HEATSINKS, FORK TERMINALS AND CONNECTOR CONTACT-BAKE ASSY AT 50 FOR 8 HRS. WITHIN 5 MIN. OF BAKE APPLY HUMISEAL TO ALL SURFACES.
1. ASSEMBLY PROCEDURES AND PROCESSES TO CONFORM WITH DANA WORKMANSHIP STANDARDS. SCHEMATIC DIAGRAM 430851.

NOTES: UNLESS OTHERWISE SPECIFIED

| | | | |
|---|---|---|---|
| 403104 | 160 | 1 | 1 |
| NEXT DWG | USED ON | NEXT ASSY | FINAL ASSY |
| APPLICATION | | QTY REQD | |

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES AND INCLUDE THICKNESS OF PLATING

TOLERANCES

| DECIMALS | ANGLES | HOLE DIAMETERS |
|---|---|---|
| X.030<br>XX.020<br>XXX.010 | ± 30'<br>FORMED<br>1° 0 | + .004<br>- .001 |

DIMENSIONS AND TOLERANCES PER USAS Y14.15

MATERIAL SEE L/M

FINISH

| | | |
|---|---|---|
| DRAWN | V.S 3-6-69 | 42769 |
| CHECK | | |
| DESIGN | | |
| MECH ENGR | | |
| PROJ ENGR | | |
| PROD ENGR | | |

Request 5/16/69

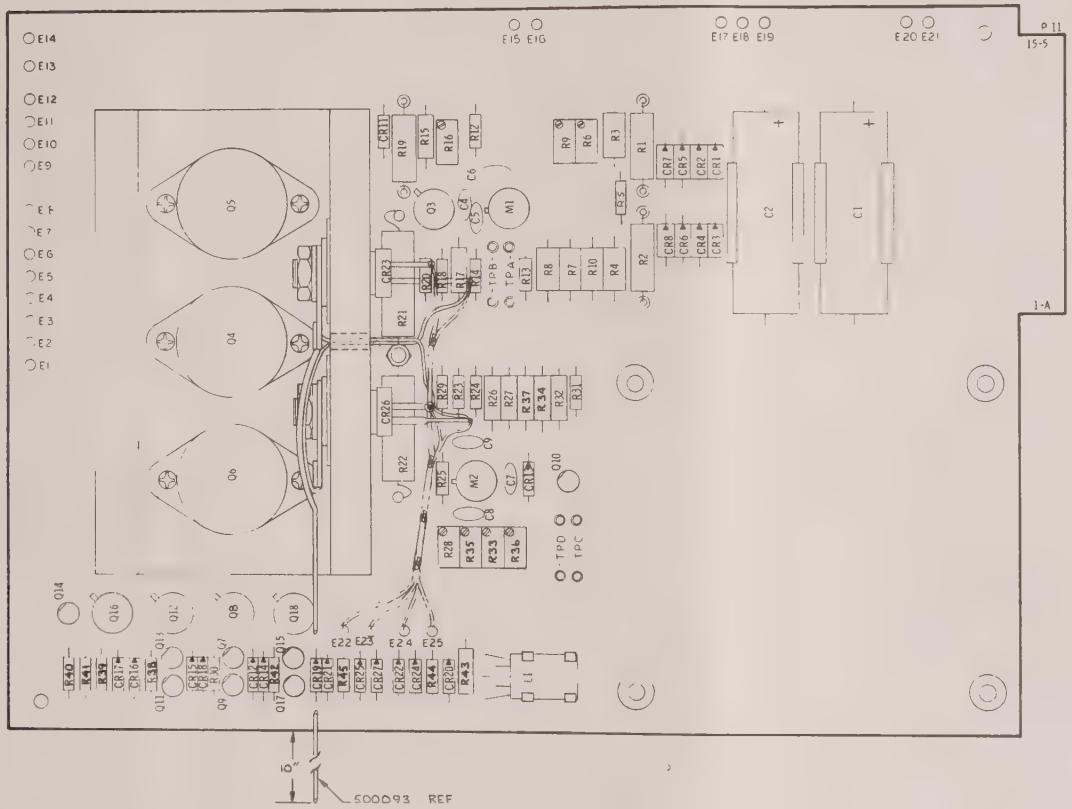
DANA DANA LABORATORIES INC. IRVINE, CALIFORNIA

# PC BOARD ASSEMBLY - CONTROL, 160

| SIZE | CODE IDENT NO | DWG NO. | REV |
|---|---|---|---|
| D | 21793 | 403106 | F |

SCALE 2/1 SHEET 2 OF 3

| REVISIONS | | | | |
|---|---|---|---|---|
| LTR | DESCRIPTION | DR | CHK | APPD |
| – | RELEASED PER DRN # 887 6 4 5 | | | |
| B | REVISED PER E.O. 4845 | | | |
| C | DELETE R11, CR9 & 10, Q1 & 2, AND C3 PER EO 5143 | | | |
| D | CORRECT REF. DESIGNATORS EO. 5351 | | | |
| E | CORRECT WIRING VIEWS, EO. 5419 | | | |
| F | 600542 WAS 600475 010022 WAS 010306 PER EO. 5516 | | | |




SEE SHEET 2

NOTES: UNLESS OTHERWISE SPECIFIED

| 403104 | 160 | 1 | 1 |
|---|---|---|---|
| NEXT DWG | USED ON | NEXT DWG | FINAL ASSY |
| APPLICATION | | QTY REQD | |

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES AND INCLUDE THICKNESS OF PLATING

TOLERANCES

| DECIMALS | ANGLES | HOLE DIAMETERS |
|---|---|---|
| X.030 | 0 30' | - 004 |
| XX.020 | FORMED | - 001 |
| XXX.010 | 1°0' | |

DIMENSIONS AND TOLERANCES PER USAS Y14.15

MATERIAL: SEE L/M SHT 3

FINISH:

| | | |
|---|---|---|
| DRAWN | V.S. 36 R.W. | 4-27-69 |
| CHECK | | |
| DESIGN | | |
| MECH ENGR | | |
| PROJ ENGR | | 5-8-69 |
| PROD ENGR | | 6/5/69 |

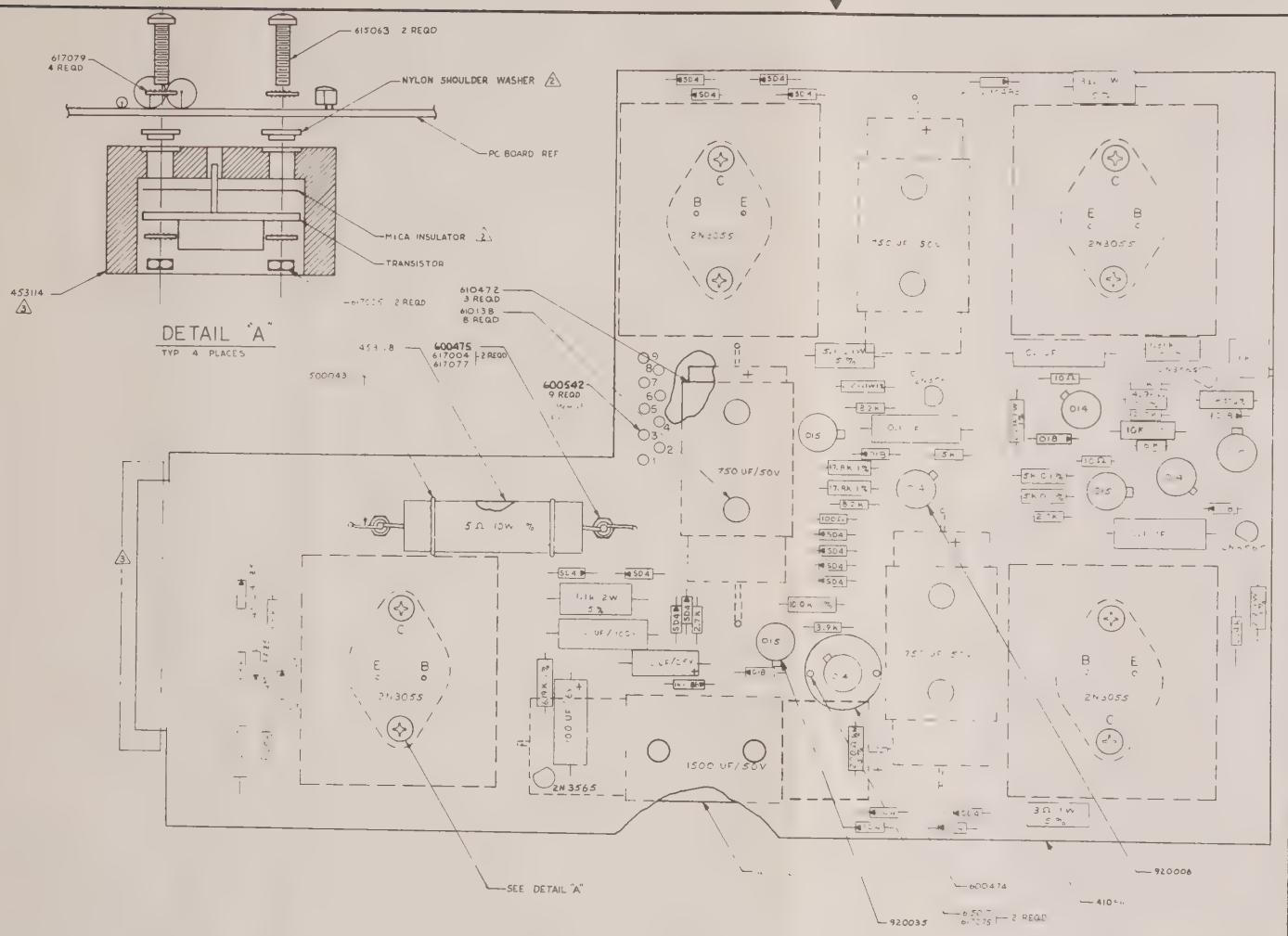
Engineering Release 5/8/69

DANA LABORATORIES INC.
IRVINE, CALIFORNIA

PCBOARD ASSEMBLY
CONTROL 160

| SIZE | CODE IDENT NO | DWG NO | REV |
|---|---|---|---|
| D | 21793 | 403106 | F |

SCALE 2/1 SHEET 1 OF 3




| REF DES OR ITEM | P/N | DESCRIPTION | QTY |
|---|---|---|---|
| C | 110106 | 1500 UF/50V | 1 |
| C2 | 111262 | 10 UF/25V | 1 |
| C3 | 120003 | 0.1 UF /100V | 4 |
| C4 | 110063 | 100 UF/6V | 1 |
| C5 | 110105 | 750 UF/50V | 3 |
| C6 | 120003 | 0.1 UF /100V | REF |
| C7 | 110105 | 750 UF/50V | REF |
| C8 | 120003 | 0.1 UF /100V | REF |
| C9 | 110105 | 750 UF/50V | REF |
| C10 | 120003 | 0.1 UF /100V | REF |
| CR1 | 210004 | SD4 | 16 |
| CR2 | 210004 | SD4 | REF |
| CR3 | 210004 | SD4 | REF |
| CR4 | 210004 | SD4 | REF |
| CR5 | 220012 | 1N9588 | 1 |
| CR6 | 211083 | 018 | 5 |
| CR7 | 220031 | 1/4m 3.3 AZ5 | 1 |
| CR8 | 221177 | 1/4M 2.4 AZ5 | 2 |
| CR9 | 210004 | SD4 | REF |
| CR10 | 210004 | SD4 | REF |
| CR11 | 210004 | SD4 | REF |
| CR12 | 210004 | SD4 | REF |
| CR13 | 220017 | 6.0V M483 | 1 |
| CR14 | 211083 | 018 | REF |
| CR15 | 211083 | 018 | REF |
| CR16 | 210004 | SD4 | REF |
| CR17 | 210004 | SD4 | REF |
| CR18 | 210004 | SD4 | REF |
| CR19 | 210004 | SD4 | REF |
| CR20 | 211083 | 018 | REF |
| CR21 | 210004 | SD4 | REF |
| CR22 | 210004 | SD4 | REF |
| CR23 | 210004 | SD4 | REF |
| CR24 | 210004 | SD4 | REF |
| CR25 | 211083 | 018 | REF |
| CR26 | 221177 | 1/4M 2.4 AZ5 | REF |
| Q1 | 200036 | 015 | 4 |
| Q2 | 200035 | 014 | 4 |
| Q3 | 200043 | 2N3565 | 4 |
| Q4 | 200092 | 2N3055 | 4 |
| Q5 | 200036 | 015 | REF |
| Q6 | 200035 | 014 | REF |
| Q7 | 200043 | 2N3565 | REF |
| Q8 | 200092 | 2N3055 | REF |
| Q9 | 200036 | 015 | REF |
| Q10 | 200035 | 014 | REF |
| Q11 | 200043 | 2N3565 | REF |
| Q12 | 200092 | 2N3055 | REF |
| Q13 | 200036 | 015 | REF |
| Q14 | 200035 | 014 | REF |
| Q15 | 200043 | 2N3565 | REF |
| Q16 | 200092 | 2N3055 | REF |
| R1 | 000392 | 3.9K | 1 |
| R2 | 030018 | 1.1K 2W 5% | 1 |
| R3 | 000152 | 1.5K | 1 |
| R4 | 000272 | 2.7K | 3 |
| R5 | 010130 | 6.19K 1% | 1 |
| R6 | 020386 | 10K .1% | 2 |
| R7 | 001695 | 200Ω 1 2W 5% | 1 |
| R8 | 020511 | 5Ω 10W 1% | 1 |

| REF DES OR ITEM | P/N | DESCRIPTION | QTY |
|---|---|---|---|
| R9 | 020540 | 1Ω 2W 1% | 1 |
| R10 | 000302 | 3K | 2 |
| R11 | 021280 | 1.3K 0.1% | 1 |
| R12 | 040138 | 1K POT | 1 |
| R13 | 020893 | 14.96K 0.1% | 1 |
| R14 | 000013 | 11K | 1 |
| R15 | 000272 | 2.7K | REF |
| R16 | 020046 | 840.1% | 1 |
| R17 | 020386 | 10K .1% | REF |
| R18 | 000100 | 10Ω | 2 |
| R19 | 030019 | 3Ω 1W 5% | 2 |
| R20 | 020542 | 2.2Ω 1W 1% | 3 |
| R21 | 020041 | 5K 0.1% | 2 |
| R22 | 020041 | 5K 0.1% | REF |
| R23 | 000063 | 16K | 1 |
| R24 | 000272 | 2.7K | REF |
| R25 | 000242 | 2.4K | 1 |
| R26 | 000100 | 10Ω | REF |
| R27 | 030019 | 3Ω 1W 5% | REF |
| R28 | 020512 | 2.2Ω 1W 1% | REF |
| R29 | 010066 | 17.8K 1% | 2 |
| R30 | 010066 | 17.8K 1% | REF |
| R31 | 000153 | 15K | 1 |
| R32 | 000822 | 8.2K | 2 |
| R33 | 000822 | 8.2K | REF |
| R34 | 000101 | 100 | 1 |
| R35 | 020685 | 5.1Ω 1W 5% | 1 |
| R36 | 020512 | 2.2Ω 1W 1% | REF |
| R37 | 000302 | 3K | REF |
| | 453114 | HEAT SINK | 4 |
| | 453118 | INSULATOR RES | 1 |
| | 508043 | WIRE 24GA TEF COATED 9 COLOR | A/R |
| | 600474 | HEAT SINK TO 5 | 1 |
| | 600475 | TERMINAL | 2 |
| | 600542 | TERMINAL | 9 |
| | 610138 | RIVET .229 LG x .129 D | 8 |
| | 610422 | CAP CLIP | 3 |
| | 610526 | CAP CLIP | REF |
| | 615017 | SCREW 2-56 x 7/16 LONG | 2 |
| | 617004 | NUT HEX NO 4 40 | 2 |
| | 617005 | NUT HEX NO 6 | 2 |
| | 617075 | WASHER NO 2 | 2 |
| | 617077 | WASHER NO 4 | 2 |
| | 617079 | WASHER NO 6 | 4 |
| | 920006 | TRANS PAD LARGE | 4 |
| | 920035 | TRANS PAD QUAL | 4 |
| | 615063 | SCR PPH 632 3/4 | 8 |
| | 410510 | PCB - POWER SUPPLY | 1 |

| REVISIONS | | | | |
|---|---|---|---|---|
| LTR | DESCRIPTION | DR | CHK | APPD |
| | RELEASED PER DRN = SEE SHT 1 | | | |

1. ALL RESISTORS ARE IN OHMS 1/4W CARBON 5%
2. MASK ALL HEATSINKS ON BOARD AND CONNECTOR CONTACTS -- ASSEMBLY TO BE BAKED AT 50°C FOR 8 HOURS. APPLY A COAT OF HUMISEAL TO ALL SURFACES.
3. APPLY A THIN COAT OF SILICONE GREASE, TO BOTH SIDES OF INSULATOR PRIOR TO ASSEMBLY. INSULATOR AND (2) SHOULDER WASHERS SUPPLIED WITH TRANSISTOR.
4. ASSEMBLY PROCEEDURES AND PROCESSES TO CONFORM TO DANA WORKMANSHIP STANDARDS. REFERENCE---SCHEMATIC 430650.

NOTES: UNLESS OTHERWISE SPECIFIED

| | | | |
|---|---|---|---|
| 403104 | 160 | 1 | 1 |
| NEXT DWG | USED ON | NEXT DWG | FINAL ASSY |
| APPLICATION | | QTY REQD | |

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES AND INCLUDE THICKNESS OF PLATING

TOLERANCES

| DECIMALS | ANGLES | HOLE DIAMETERS |
|---|---|---|
| X .030 | 0 30 | .004 |
| XX .020 | FORMED | .001 |
| XXX .010 | 1 0° | |

DIMENSIONS AND TOLERANCES PER USAS Y14.15

MATERIAL | FINISH

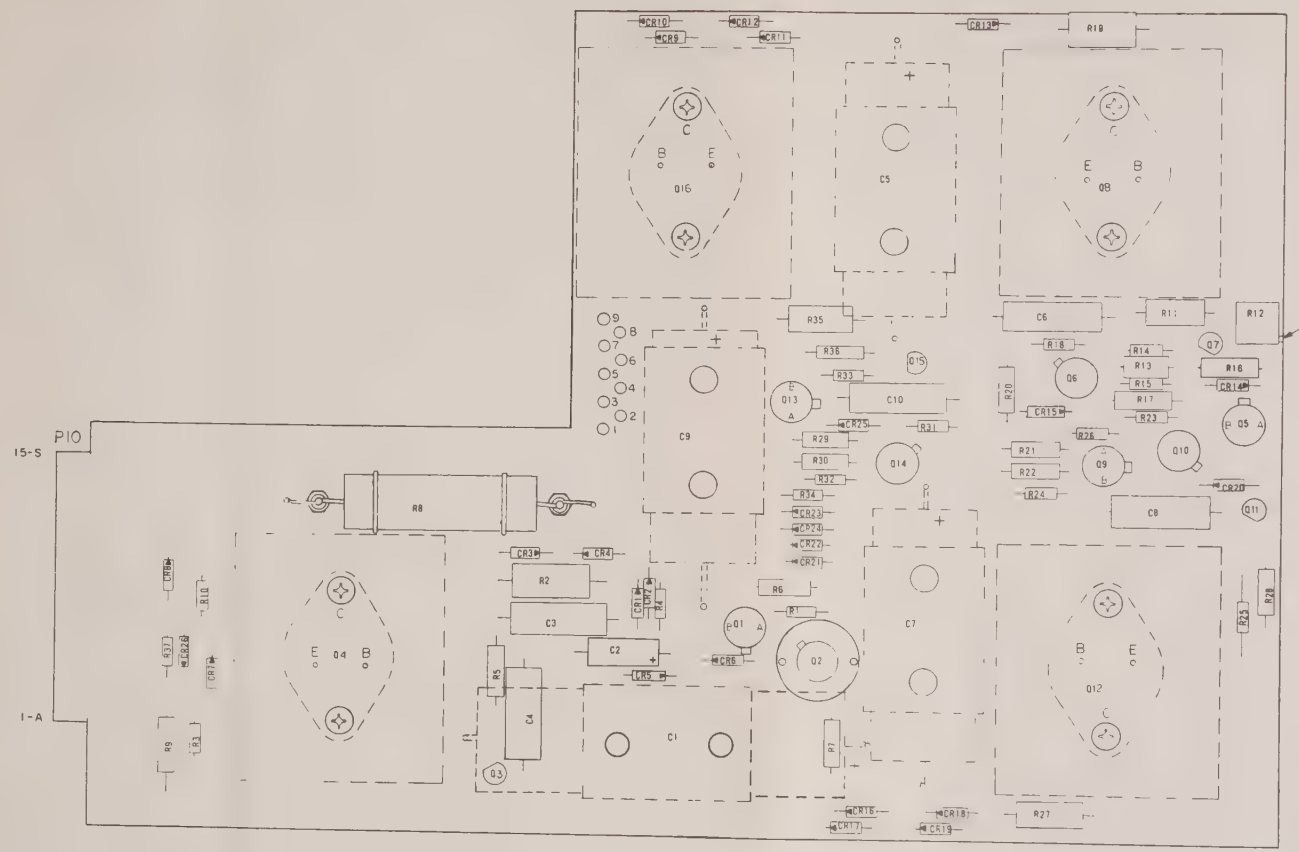
| | | |
|---|---|---|
| DRAWN | [illegible] | [illegible] |
| CHECK | [illegible] | 3/4/74 |
| DESIGN | P. GUMMERSON | 12-19-73 |
| MECH ENGR | | |
| PROJ ENGR | | |
| PROD ENGR | | |

DANA LABORATORIES INC
IRVINE, CALIFORNIA

PC BOARD ASSY - POWER SUPPLY, 160

| SIZE | CODE IDENT NO | DWG NO | REV |
|---|---|---|---|
| D | 21793 | 403105 | D |

SCALE 2/1 SHEET 2 OF 2




| REVISIONS | | | | |
|---|---|---|---|---|
| LTR | DESCRIPTION | DR | CHK | APPD |
| A | RELEASED PER DAN # 497 6-1-9 | | | |
| B | REVISED PER ED 4844 | | | |
| C | CHANGE QTY ON 403104 TO 4 EA | | | |

2. ASSEMBLY DETAILS, COMP. VALUES AND L/W ON SHT. 2 OF 2
1. REFFERENCE SCHEMATIC 430[illegible]

NOTES UNLESS OTHERWISE SPECIFIED

| | | | |
|---|---|---|---|
| 403104 | 160 | 1 | 1 |
| NEXT DWG | USED ON | REQ'D DWG | FINAL ASSY |
| APPLICATION | | QTY REQD | |

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES AND INCLUDE THICKNESS OF PLATING

TOLERANCES

| DECIMALS | ANGLES | HOLE DIAMETERS |
|---|---|---|
| X .030<br>XX .020<br>XXX .010 | 0-30' FORMED<br>1 0' | ± .004<br>.001 |

DIMENSIONS AND TOLERANCES PER USAS Y14.15

MATERIAL | FINISH

| | | |
|---|---|---|
| DRAWN | R.T.WELLMAN | 12-19-79 |
| CHECK | [illegible] | 12-19-79 |
| DESIGN | P. GEMMERSON | 12-19-79 |
| MECH ENGR | | |
| PROJ ENGR | D. MacKenzie | 5-5-4 |
| PROD ENGR | [illegible] | [illegible] |

Document 5/84

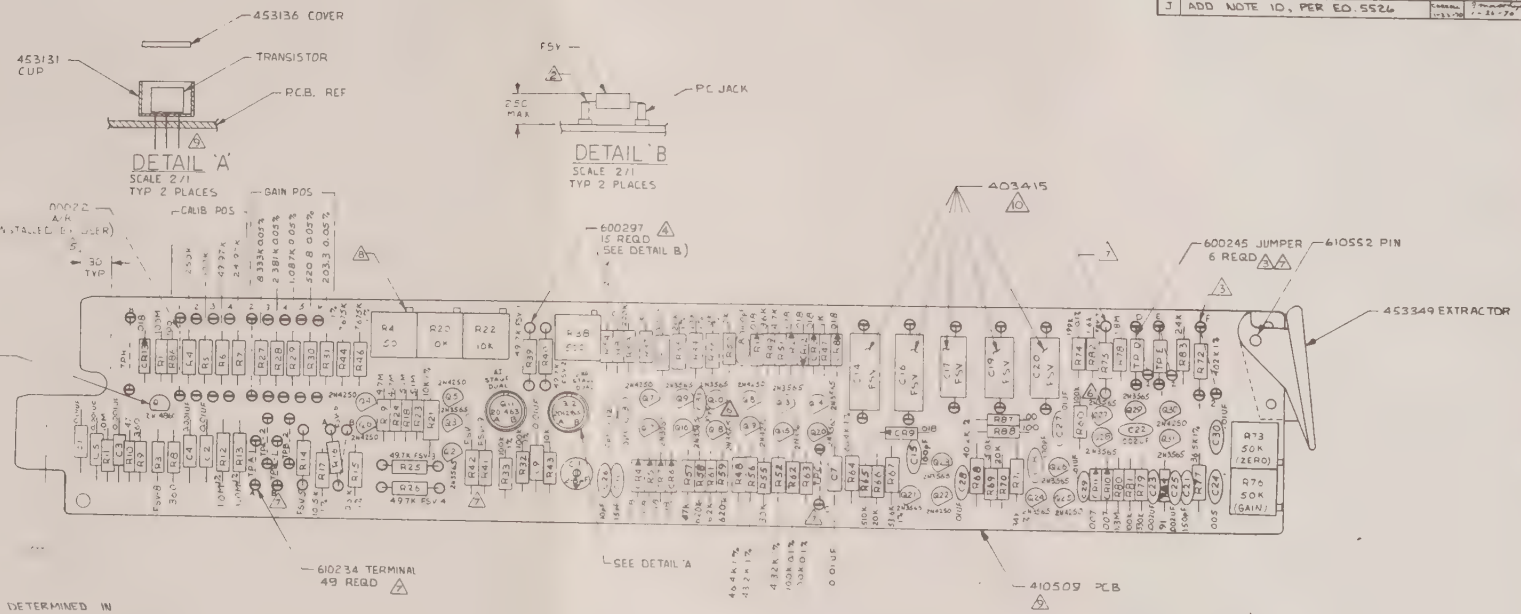
DANA DANA LABORATORIES INC.
IRVINE, CALIFORNIA

# PC BOARD ASSY – POWER SUPPLY, 160

| SIZE | CODE IDENT NO | DWG NO | REV |
|---|---|---|---|
| D | 21793 | 403105 | D |

SCALE 2/1 SHEET 1 OF 2

| REVISIONS | | | | |
|---|---|---|---|---|
| LTR | DESCRIPTION | DR | CHK | APPD |
| A | RELEASED PER DRN # 887 6-69 | | | |
| B | RE-DESIGNED PER E.O. 4841 | | | |
| C | CHANGE Q1 FROM TIS74 TO 2N4860 PER EO. 5026 | | | |
| D | REVISED PER EO 5109 | | | |
| E | CHANGE 100019 TO 100028, ADD 100017 PER ED 5146 | | | |
| F | REVISE NOTE 6. PER EO 5282 | | | |
| H | 454349 WAS 610548, 610552 WAS 610237 PER EO 5396 | | | |
| J | ADD NOTE 10, PER EO. 5526 | | | |




1. CAPACITORS C14,16,17,19,20, VALUES ARE DETERMINED IN FSV ASSY FILTER CAP 403415
2. COMPONENT LEADS AND SOLDER NOT TO EXTEND BEYOND .062 FROM PC BOARD SURFACE.
3. APPLY 920430 TORQUE PAINT TO LOCK POT. ADJUSTMENT SCREW OF R20, R22, R34 and R45 AFTER FINAL CALIBRATION.
4. JUMPER P/N 600245 TO BE MOUNTED AT TP-D, TP-E, FSV 7,8,9 AND 10. REMAINING TP & FSV'S TO BE MOUNTED DURING CHECKOUT.
5. ALL RESISTORS ARE IN OHMS, 1/4 CARBON ±5%, TRANSISTORS ARE 2N3565, Q9 & Q10 ARE MATCHED 2N3565 P/N 200044, Q29 IS SELECTED 2N3565 P/N 200122, Q27 & Q28 ARE MATCHED 2N3565 P/N 200121, Q31 IS SELECTED 2N3565 P/N 200120.
6. HUMISEAL-ASSEMBLY TO BE BAKED AT 50°C FOR 8 HRS. MIN. DIP HUMISEAL (WITHIN ONE HOUR OF BAKE) ALL SURFACES, EXCLUDING CONTACTS TO DIM. SHOWN. BOARD WIDTH NOT TO EXCEED 2.002. THICKNESS NOT TO EXCEED .072 AT EDGES MAKING CONTACT WITH CARD GUIDES.
7. FSV COMPONENTS AND SELECTION PROCEDURES ARE INCLUDED IN FSV ASSEMBLY DRAWING P/N 403167.
8. JUMPER WIRE MOUNTED TO FORKED TERMINALS WILL BE WRAPPED OR BENT AGAINST TERMINAL BODY - NO OVERHANG TOWARD P.C. BOARD EDGE OR OTHER TERMINALS.
9. FSV LEADS TO BE FLUSH TO P.C. JACK BEFORE SOLDERING
10. ASSY PROCEDURES AND PROCESSES TO CONFORM TO DANA WORKMANSHIP STANDARDS. REFERENCE - SCHEMATIC 430849.

NOTES: UNLESS OTHERWISE SPECIFIED

| | | | |
|---|---|---|---|
| 403213 | 160 B | 160 | 160 |
| 400952 | 160 A | 160 | 160 |
| NEXT DWG | USED ON | NEXT ASSY | FINAL ASSY |
| APPLICATION | | QTY REQD | |

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES AND INCLUDE THICKNESS OF PLATING

TOLERANCES

| DECIMALS | ANGLES | HOLE DIAMETERS |
|---|---|---|
| X .030 | 0° 30' | + .004 |
| XX .020 | FORMED | - .001 |
| XXX .010 | 1° 0 | |

DIMENSIONS AND TOLERANCES PER USAS Y14.15

MATERIAL | FINISH

| | | |
|---|---|---|
| DRAWN | RON WELLMAN | 6-25-69 |
| CHECK | W. E. Sullivan | |
| DESIGN | W. E. Sullivan | |
| MECH ENGR | | |
| PROJ ENGR | D. M. Mayo | 6-29-69 |
| PROJ ENGR | R. Johnson | 6-3-69 |

REINERT 5-2-9

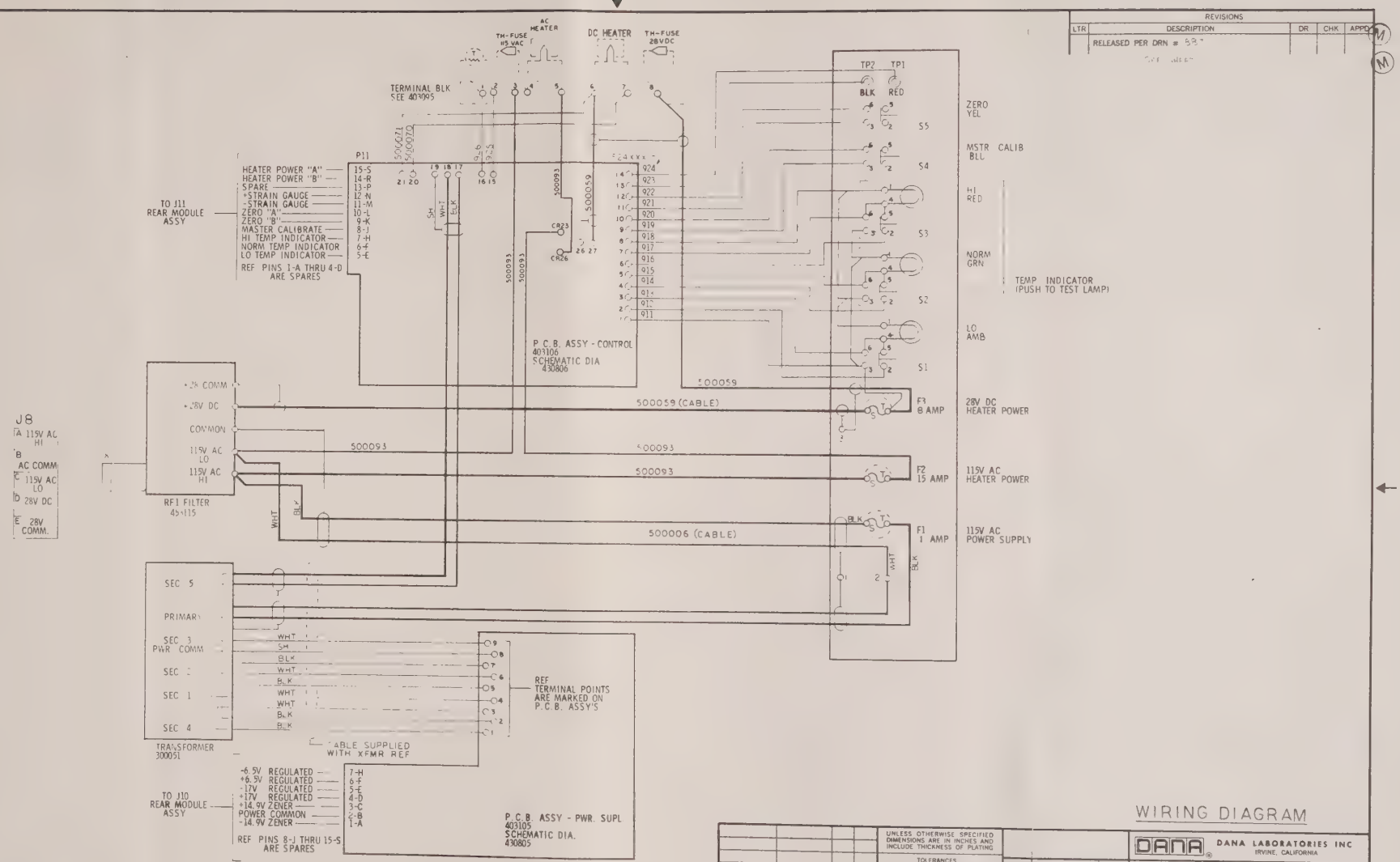
DANA DANA LABORATORIES INC.
IRVINE, CALIFORNIA

P.C. BOARD ASSY - AMPLIFIER 2550

| SIZE | CODE IDENT NO. | DWG NO. | REV |
|---|---|---|---|
| D | 21793 | 403085 | J |

SCALE 2/1 SHEET 1 OF 1

BAT 8-6




| REVISIONS | | | | |
|---|---|---|---|---|
| LTR | DESCRIPTION | DR | CHK | APPD |
| | RELEASED PER DRN # 52? | | | |

NOTES: UNLESS OTHERWISE SPECIFIED

| | | | |
|---|---|---|---|
| 403235 | 160 B | 1 | 1 |
| 403090 | 160 A | 1 | 1 |
| NEXT DWG | USED ON | NOT CHG | FINAL ASSY |
| APPLICATION | | QTY REQD | |

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES AND INCLUDE THICKNESS OF PLATING

TOLERANCES

| DECIMALS | ANGLES | HOLE DIAMETERS |
|---|---|---|
| X .030 | 0° 30' | .004 |
| XX .020 | FORMED | .001 |
| XXX .010 | 1 0° | |

DIMENSIONS AND TOLERANCES PER USAS Y14.15

MATERIAL: SEE L/M

FINISH:

| | | |
|---|---|---|
| DRAWN | | |
| CHECK | A. Momoy | 4-29-69 |
| DESIGN | A.N. Esquivel | 4-29-69 |
| TECH ENGR | Bill Williams | 5-1-69 |
| PROJ ENGR | R.D. Mark | 5-5-69 |
| PROD ENGR | L. Johnson | 5-3-69 |

Released 5/8/69

WIRING DIAGRAM

DANA DANA LABORATORIES INC IRVINE, CALIFORNIA

BOTTOM PANEL ASSY-
160 ENCLOSURE

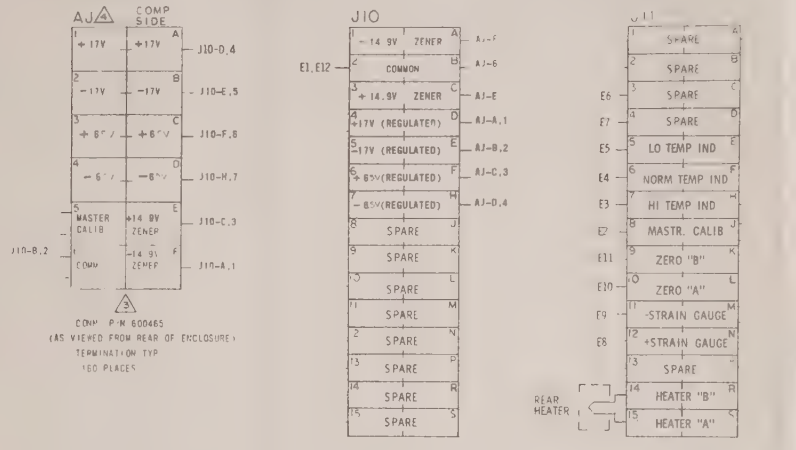
| SIZE | CODE IDENT NO | DWG NO | REV |
|---|---|---|---|
| D | 21793 | 403104 | D |

SCALE —

SHEET 3 OF 7

| REVISIONS | | | | |
|---|---|---|---|---|
| LTR | DESCRIPTION | DR | CHK | APPD |
| A | RELEASED PER DRN # 887 | | | |

P C B ASSY
INTERCONNECTION 'A'
(P/N 403092)

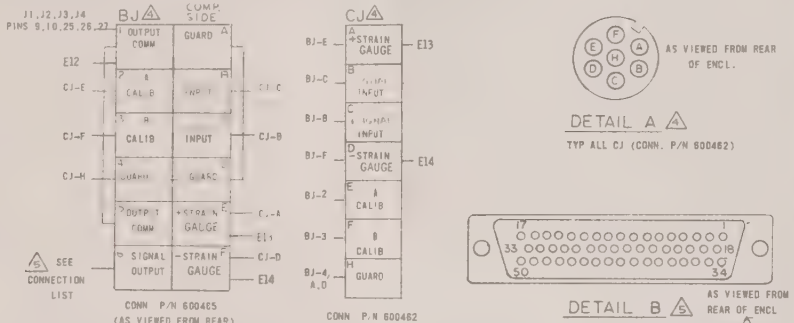



CONN P/N 600465
(AS VIEWED FROM REAR OF ENCLOSURE)
TERMINATION TYP
160 PLACES

CONN P/N 600335

CONN P/N 600335

P C B ASSY
INTERCONNECTION 'B'
(P/N 403093)




CONN P/N 600465
(AS VIEWED FROM REAR)

CONN P/N 600462




AS VIEWED FROM REAR OF ENCL.

DETAIL A 4
TYP ALL CJ (CONN. P/N 600462)



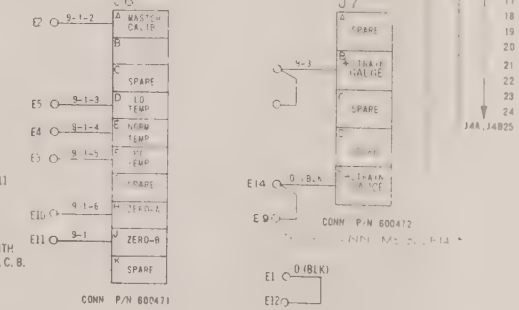

DETAIL B 5
TYP. J1 THRU J4 (CONN P/N 600463) 8

AS VIEWED FROM REAR OF ENCL

## CONNECTION LIST 5

| FROM | TO BJ- | FROM | TO BJ- | FROM | TO BJ- | FROM | TO BJ- | FROM | TO BJ- | FROM | TO BJ- |
|---|---|---|---|---|---|---|---|---|---|---|---|
| J4A,J4B-1 | 350-6 | J4A,J4B-26 | COM | J3A,J3B-1 | 150-6 | J3A,J3B-26 | COM | J2A,J2B-1 | 110-6 | J2A,J2B-26 | COM | J1A,J1B-1 | 70-6 | J1A,J1B-26 | COM |
| 2 | 354-8 | 27 | COM | 2 | 314-6 | 27 | COM | 2 | 114-6 | 27 | COM | 2 | 74-6 | 27 | COM |
| 3 | 355-6 | 28 | SPR | 3 | 315-6 | 28 | KEY | 3 | 115-6 | 28 | SPR | 3 | 75-6 | 28 | SPR |
| 4 | 359-6 | 29 | KEY | 4 | 319-6 | 29 | SPR | 4 | 119-6 | 29 | SPR | 4 | 79-6 | 29 | SPR |
| 5 | 363-6 | 30 | 362-6 | 5 | 323-6 | 30 | 322-6 | 5 | 123-6 | 30 | 122-6 | 5 | 83-6 | 30 | 82-6 |
| 6 | 357-6 | 31 | 367-6 | 6 | 317-6 | 31 | 327-6 | 6 | 117-6 | 31 | 127-6 | 6 | 77-6 | 31 | 87-6 |
| 7 | 358-6 | 32 | 368-6 | 7 | 318-6 | 32 | 328-6 | 7 | 118-6 | 32 | 128-6 | 7 | 78-6 | 32 | 88-6 |
| 8 | 361-6 | 33 | 366-6 | 8 | 320-6 | 33 | 326-6 | 8 | 120-6 | 33 | 126-6 | 8 | 80-6 | 33 | 86-6 |
| 9 | COM | 34 | 347-6 | 9 | COM | 34 | 147-8 | 9 | COM | 34 | 107-8 | 9 | COM | 34 | 67-6 |
| 10 | COM | 35 | 353-6 | 10 | COM | 35 | 313-8 | 10 | COM | 35 | 113-8 | 10 | COM | 35 | 73-8 |
| 11 | 356-6 | 36 | 349-6 | 11 | 316-6 | 36 | 149-6 | 11 | 116-6 | 36 | 109-6 | 11 | 76-6 | 36 | 69-6 |
| 12 | 361-6 | 37 | 342-8 | 12 | 321-6 | 37 | 142-8 | 12 | 121-8 | 37 | 102-6 | 12 | 81-6 | 37 | 62-8 |
| 13 | 364-6 | 38 | 345-8 | 13 | 324-6 | 38 | 145-6 | 13 | 124-8 | 38 | 105-6 | 13 | 84-6 | 38 | 65-6 |
| 14 | 365-6 | 39 | 344-6 | 14 | 325-8 | 39 | 144-6 | 14 | 125-6 | 39 | 104-6 | 14 | 85-6 | 39 | 64-6 |
| 15 | 369-6 | 40 | 343-6 | 15 | 329-6 | 40 | 143-6 | 15 | 129-6 | 40 | 103-6 | 15 | 89-6 | 40 | 63-6 |
| 16 | 373-6 | 41 | 341-8 | 16 | 333-6 | 41 | 141-6 | 16 | 133-6 | 41 | 101-6 | 16 | 93-6 | 41 | 61-6 |
| 17 | 370-6 | 42 | 376-6 | 17 | 330-6 | 42 | 336-6 | 17 | 130-6 | 42 | 136-6 | 17 | 90-6 | 42 | 96-6 |
| 18 | 348-6 | 43 | 380-6 | 18 | 148-6 | 43 | 340-6 | 18 | 108-6 | 43 | 140-8 | 18 | 68-6 | 43 | 100-6 |
| 19 | 346-6 | 44 | 378-6 | 19 | 146-6 | 44 | 338-6 | 19 | 106-6 | 44 | 138-6 | 19 | 66-6 | 44 | 98-6 |
| 20 | 351-6 | 45 | 377-6 | 20 | 311-6 | 45 | 337-6 | 20 | 111-6 | 45 | 137-6 | 20 | 71-6 | 45 | 67-6 |
| 21 | 352-6 | 46 | 372-6 | 21 | 312-8 | 46 | 332-6 | 21 | 112-6 | 46 | 132-6 | 21 | 72-6 | 46 | 92-6 |
| 22 | SPR | 47 | 375-6 | 22 | SPR | 47 | 335-6 | 22 | SPR | 47 | 135-6 | 22 | SPR | 47 | 95-6 |
| 23 | SPR | 48 | 374-6 | 23 | SPR | 48 | 334-6 | 23 | SPR | 49 | 134-6 | 23 | KEY | 48 | 94-6 |
| 24 | SPR | 49 | 379-6 | 24 | SPR | 49 | 339-6 | 24 | KEY | 49 | 139-6 | 24 | SPR | 49 | 59-6 |
| J4A,J4B25 | COM | J4A,J4B 50 | 371-6 | J3A,J3B-25 | COM | J3A,J3B 50 | 331-6 | J2A,J2B 25 | COM | J2A,J2B 50 | 131-8 | J1A,J1B 25 | COM | J1A,J1B 50 | 91-6 |

REAR MODULE ASSY 6 7
(P/N 403091)




CONN P/N 600471

CONN P/N 600472

8 MECHANICAL KEYING WAS ACHIEVED BY FILLING ONE SOCKET ON EACH OUTPUT CONNECTOR WITH SOLDER AS FOLLOWS- J1A&B -SOCKET #25. J2A&B -SOCKET #24, J3A&B -SOCKET #28, J4A&B -SOCKET #29

1 ALL WIRING IS STRANDED, TEFLON COATED - WIRE FROM J6 IS 24 AWG, WIRING FROM J7 IS 18 AWG.

6 "E" NUMBERS CORRESPOND WITH TERMINAL POSTS ON P. C. B. ASSY'S E1 THRU E11 ARE ON P/N 403092, E12 - E14 ARE ON P/N 403093.

5 SIGNAL OUTPUT IS TERMINATED ON P. C. B. ASSY PER CONNECTION LIST-TWO 50 PIN CONNECTORS ARE ELECTRICALLY PARALLED FOUR PLACES.

4 "J" NUMBER WILL CORRESPOND WITH AMPLIFIER CHANNEL NUMBER.
EXAMPLE: A J101" TO AMPLIFIER CHANNEL "101" ONE AMPLIFIER WILL JOIN WITH "AJ101" AND "BJ101" SIMULTANEOUSLY "BJ101 and CJ101 ARE TERMINATED ON P. C. B. ASSY - P/N 403093.

3 TERMINATION NOTED IS ELECTRICALLY PARALLED TO ALL 600465 CONNECTORS SHOWN ON THE SAME P. C. B. ASSY.

2. CONNECTIONS SHOWN OR NOTED ARE ON PRINTED WIRING BOARDS UNLESS WIRE COLOR IS SPECIFIED.

1. REF. THE REAR MODULE IS A MECHANICAL AND ELECTRICAL ASSEMBLY OF REAR PANEL, BRACKETS AND TWO P. C. BOARD SUBASSEMBLYS.

NOTES. UNLESS OTHERWISE SPECIFIED

| | | | |
|---|---|---|---|
| 403091 | 160 A | REF | REF |
| NEXT DWG | USED ON | NEXT ASSY | NEXT ASSY |
| APPLICATION | | QTY REQD | |

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES AND INCLUDE THICKNESS OF PLATING

TOLERANCES

| DECIMALS | ANGLES | HOLE DIAMETERS |
|---|---|---|
| X .030 | 0° 30' FORMED | .004 |
| XX .020 | 1° 0' | .001 |
| XXX .010 | | |

DIMENSIONS AND TOLERANCES PER USAS Y14.15

MATERIAL | FINISH

| | |
|---|---|
| DRAWN | |
| CHECK | |
| DESIGN | E. D. Sellers 1 MAR 67 |
| MECH ENGR | |
| PROJ ENGR | |
| PROD ENGR | |

DANA DANA LABORATORIES INC.
IRVINE, CALIFORNIA

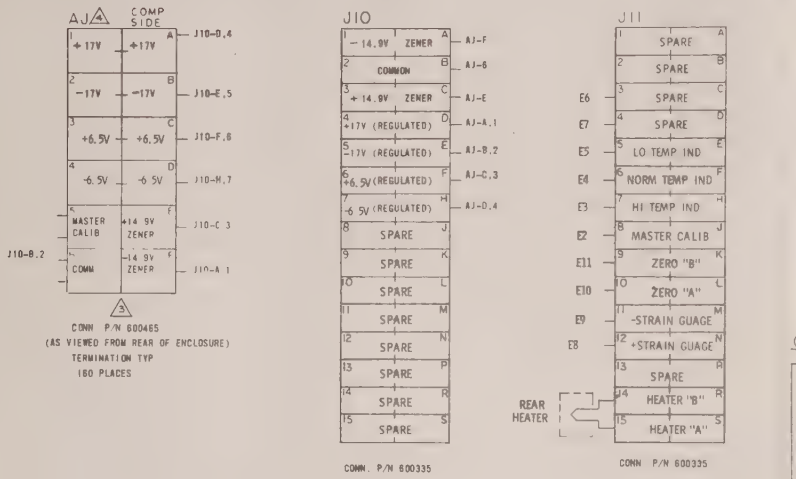
# CONNECTION DIAGRAM- REAR MODULE 160 A

| SIZE | CODE IDENT NO | DWG NO | REV |
|---|---|---|---|
| D | 21793 | 430852 | 1/A |

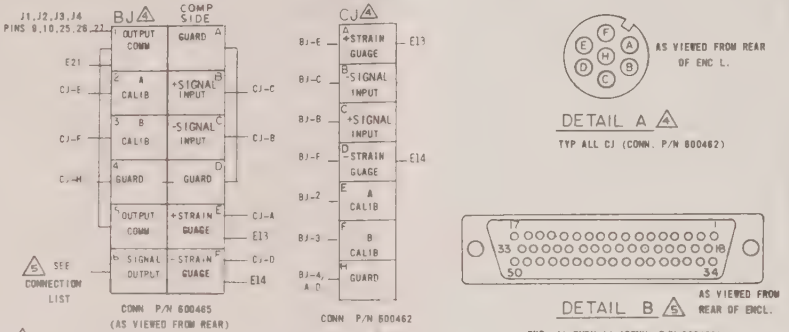
SCALE | SHEET 1 OF 1

| REVISIONS | | | | |
|---|---|---|---|---|
| LTR | DESCRIPTION | DR | CHK | APPD |
| A | RELEASED PER DRN # 888 c 59 | | | |

P.C.B. ASSY. INTERCONNECTION 'A' (P/N 403092)

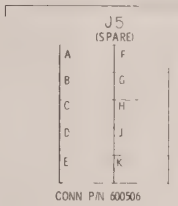



P.C.B. ASSY INTERCONNECTION 'B' (P/N 403093)

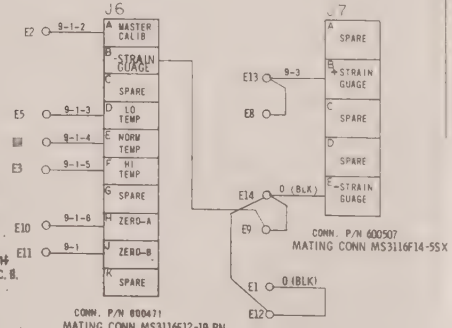



CONNECTION LIST 5

| FROM | TO BJ- | FROM | TO BJ- | FROM | TO BJ- | FROM | TO BJ- | FROM | TO BJ- | FROM | TO BJ- | FROM | TO BJ- |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| J4A,J4B-1 | 280-6 | J4A,J4B-26 | COM | J3A,J3B-1 | 240-6 | J3A,J3B-26 | COM | J2A,J2B-1 | 200-6 | J2A,J2B-26 | COM | J1A,J1B-1 | 160-6 | J1A,J1B-26 | COM |
| 2 | 284-6 | 27 | COM | 2 | 244-6 | 27 | COM | 2 | 204-6 | 27 | COM | 2 | 164-6 | 27 | COM |
| 3 | 285-6 | 28 | SPR | 3 | 245-6 | 28 | KEY | 3 | 205-6 | 28 | [illegible] | 3 | 165-6 | 28 | SPR |
| 4 | 288-6 | 29 | KEY | 4 | 248-6 | 29 | [illegible] | 4 | 208-6 | 29 | SPR | 4 | 168-6 | 29 | SPR |
| 5 | 293-6 | 30 | 292-6 | 5 | 253-6 | 30 | 252-6 | 5 | 213-6 | 30 | 212-6 | 5 | 173-6 | [illegible] | 172-6 |
| 6 | 287-6 | 31 | 297-6 | 6 | 247-6 | 31 | 257-6 | 6 | 207-6 | 31 | 217-6 | 6 | 167-6 | 31 | 177-6 |
| 7 | 288-6 | 32 | 298-6 | 7 | 248-6 | 32 | 258-6 | 7 | 208-6 | 32 | 218-6 | 7 | 168-6 | 32 | 178-6 |
| 8 | 280-6 | 33 | 296-6 | 8 | 250-6 | 33 | 256-6 | 8 | 210-6 | 33 | 216-6 | 8 | 170-6 | 33 | 176-6 |
| 9 | COM | 34 | 277-6 | 9 | COM | 34 | 237-6 | 9 | [illegible] | 34 | 197-6 | 9 | COM | 34 | 167-6 |
| 10 | COM | 35 | 283-6 | 10 | COM | 35 | 243-6 | 10 | COM | 35 | 203-6 | 10 | COM | 35 | 163-6 |
| 11 | 286-6 | 36 | 279-6 | 11 | 246-6 | 36 | 239-6 | 11 | 206-6 | 36 | 199-6 | 11 | 166-6 | [illegible] | 159-6 |
| 12 | 291-6 | 37 | 272-6 | 12 | 251-6 | 37 | 232-6 | 12 | 211-6 | 37 | 192-6 | 12 | 171-6 | 37 | 152-6 |
| 13 | 294-6 | 38 | 275-6 | 13 | 254-6 | 38 | 235-6 | 13 | 214-6 | 38 | 195-6 | 13 | 174-6 | [illegible] | 155-6 |
| 14 | 295-6 | 39 | 274-6 | 14 | 255-6 | 39 | 234-6 | 14 | 215-6 | 39 | 194-6 | 14 | 175-6 | 39 | 154-6 |
| 15 | 299-6 | 40 | 273-6 | 15 | 259-6 | 40 | 233-6 | 15 | 219-6 | [illegible] | 193-6 | 15 | 179-6 | 40 | 153-6 |
| 16 | 303-6 | 41 | 271-6 | 16 | 263-6 | 41 | 231-6 | 16 | 223-6 | 41 | 191-6 | 16 | 183-6 | 41 | 151-6 |
| 17 | 300-6 | 42 | 306-6 | 17 | 260-6 | 42 | 266-6 | 17 | 220-6 | 42 | 226-6 | 17 | 180-6 | 42 | 186-6 |
| 18 | 278-6 | 43 | 310-6 | 18 | 238-6 | 43 | 270-6 | 18 | 198-6 | 43 | 230-6 | 18 | 158-6 | 43 | 190-6 |
| 19 | 276-6 | 44 | 308-6 | 19 | 236-6 | 44 | 268-6 | 19 | 196-6 | 44 | 228-6 | 19 | 156-6 | 44 | 188-6 |
| 20 | 281-6 | 45 | 307-6 | 20 | 241-6 | 45 | 267-6 | 20 | 101-6 | 45 | 227-6 | 20 | 161-6 | 45 | 187-6 |
| 21 | 282-6 | 46 | 302-6 | 21 | 242-6 | [illegible] | 262-6 | 21 | 102-6 | 46 | 222-6 | 21 | 162-6 | 46 | 182-6 |
| 22 | SPR | 47 | 305-6 | 22 | SPR | 47 | 265-6 | 22 | SPR | 47 | 225-6 | 22 | SFR | 47 | 185-6 |
| 23 | SPR | 48 | 304-6 | 23 | SPR | [illegible] | 264-6 | 23 | SPR | 48 | 224-6 | 23 | KEY | 48 | 184-6 |
| 24 | SPR | 49 | 308-6 | 24 | SPR | 49 | 269-6 | 24 | KEY | 49 | 229-6 | 24 | SPR | 49 | 189-6 |
| J4A,J4B25 | COM | J4A,J4B 50 | 301-6 | J3A,J3B-25 | COM | J3A,J3B 50 | 261-6 | J2A,J2B 25 | COM | J2A,J2B 50 | 221-6 | J1A,J1B 25 | COM | J1A,J1B 50 | 181-6 |




REAR MODULE ASSY. 6 7 (P/N 403236)




1. 1 ALL WIRING IS STRANDED, TEFLON COATED - WIRE FROM J6 IS 24 AWG, WIRING FROM J7 IS 18 AWG.
2. 6 "E" NUMBERS CORRESPOND WITH TERMINAL POSTS ON P.C.B. ASSY'S E1 THRU E8 ARE ON P/N 403092, E12,13 & 14 ARE ON P/N 403093.
3. 5 SIGNAL OUTPUT IS TERMINATED ON P.C.B. ASSY PER CONNECTION LIST-TWO 50 PIN CONNECTORS ARE ELECTRICALLY PARALLED FOUR PLACES.
4. 4 "J" NUMBER WILL CORRESPOND WITH AMPLIFIER CHANNEL NUMBER.
   EXAMPLE: A J101" TO AMPLIFIER CHANNEL "101" ONE AMPLIFIER WILL JOIN WITH "AJ101" AND "BJ101" SIMULTANEOUSLY "BJ101 and CJ101 ARE TERMINATED ON P.C.B. ASSY - P/N 403093
5. 3 TERMINATION NOTED IS ELECTRICALLY PARALLED TO ALL 600465 CONNECTORS SHOWN ON THE SAME P.C.B. ASSY.
2. CONNECTIONS SHOWN OR NOTED ARE ON PRINTED WIRING BOARDS UNLES WIRE COLOR IS SPECIFIED.
1. REF. THE REAR MODULE IS A MECHANICAL AND ELECTRICAL ASSEMBLY OF REAR PANEL, BRACKETS AND TWO P.C. BOARD SUBASSEMBLYS.

NOTES: UNLESS OTHERWISE SPECIFIED

| 403236 | 160B | REF | REF |
|---|---|---|---|
| NEXT DWG | USED ON | NEXT ASSY | FINAL ASSY |
| APPLICATION | | QTY REQD | |

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES AND INCLUDE THICKNESS OF PLATING

TOLERANCES

| DECIMALS | ANGLES | HOLE DIAMETERS |
|---|---|---|
| X .030 | 0° 30' | + .004 |
| XX .020 | FORMED | - .001 |
| XXX .010 | 1° 0' | |

DIMENSIONS AND TOLERANCES PER USAS Y14.15

MATERIAL | FINISH

| | | |
|---|---|---|
| DRAWN | | |
| CHECK | J MONROY | 4 June 1969 |
| DESIGN | | 8 Aug 1968 |
| MECH ENGR | | 6-4-69 |
| PROJ ENGR | | 6-4-69 |
| PROD ENGR | | 6-4-69 |

Recent 6/4/69

DANA DANA LABORATORIES INC. IRVINE, CALIFORNIA

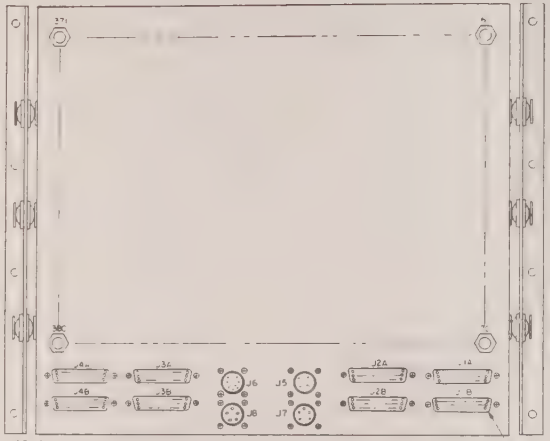
# CONNECTION DIAGRAM - REAR MODULE 160 B CHNL 151 THRU 310

| SIZE | CODE IDENT NO | DWG NO | REV |
|---|---|---|---|
| D | 21793 | 430853 | |

SCALE | SHEET 1

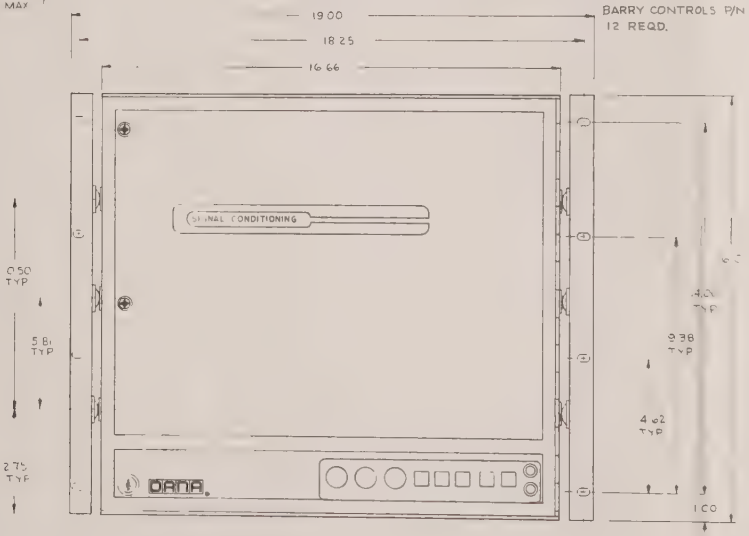
| REVISIONS | | | | |
|---|---|---|---|---|
| LTR | DESCRIPTION | DR | CHK | APPD |
| A | REL PER DWG # | | | |

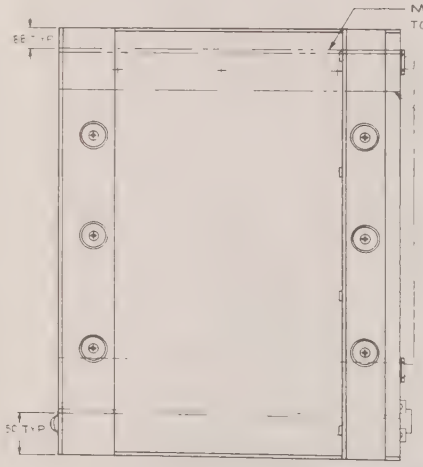
VIBRATION ISOLATOR BARRY CONTROLS P/N N6300-11 12 REQD.




REAR VIEW

50 PIN CONNECTOR DESIGNED TO MEET MIL-C-8384 B TYP 8 PLACES




— 453268 TOP, RIGHT REF ⚠ ALSO USED BOTTOM LEFT IN INVERTED POSITION

⚠ UNIT SUPPLIED WITH FRONT AND REAR MOUNTING FLANGES AS SHOWN WHEN MOUNTING TOP AND BOTTOM, INSTALL ISOLATORS IN MOUNTING FLANGES P/N 453267 AND 453268 THEN INSTALL AS SHOWN ON UNIT

NOTES UNLESS OTHERWISE SPECIFIED

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
TOLERANCES ON DECIMALS: X .030, XX .020, XXX .010; ANGLES 0 30' FORMED 1 0'; HOLE DIAMETERS .004 .001

MATERIAL

FINISH

| | | | |
|---|---|---|---|
| DRAWN | J. Monroy | 11 OCT .968 | |
| CHECK | W. Stevens | 11 OCT .968 | |
| DESIGN | W. G. Stevens | 11 OCT .968 | |
| MECH ENGR | | 11 OCT .968 | |
| PROJ ENGR | | 6-3-9 | |
| | | 3 67 | |

| NEXT DWG | USED ON | NEXT ASSY | FINAL ASSY |
|---|---|---|---|
| APPLICATION | | QTY REQD | |

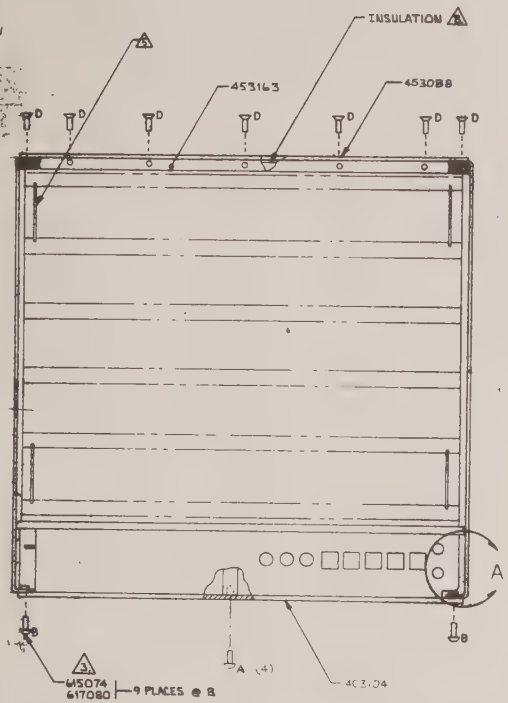
DANA LABORATORIES INC
IRVINE CALIFORNIA

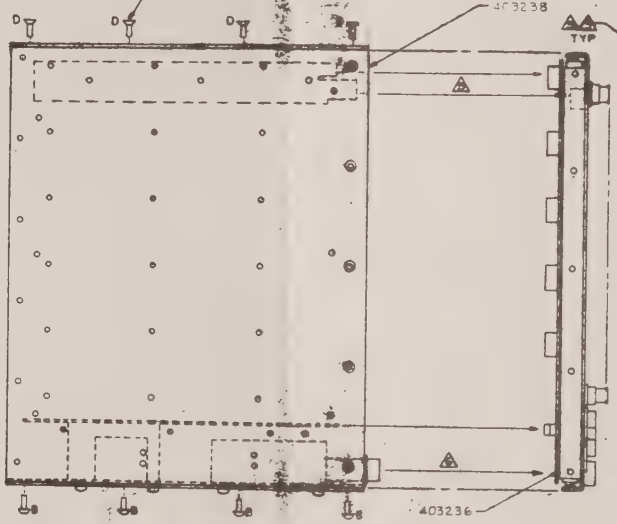
# DIMENSIONAL OUTLINE - SIGNAL CONDITIONING SYSTEM MODEL 160 (2 REQD)

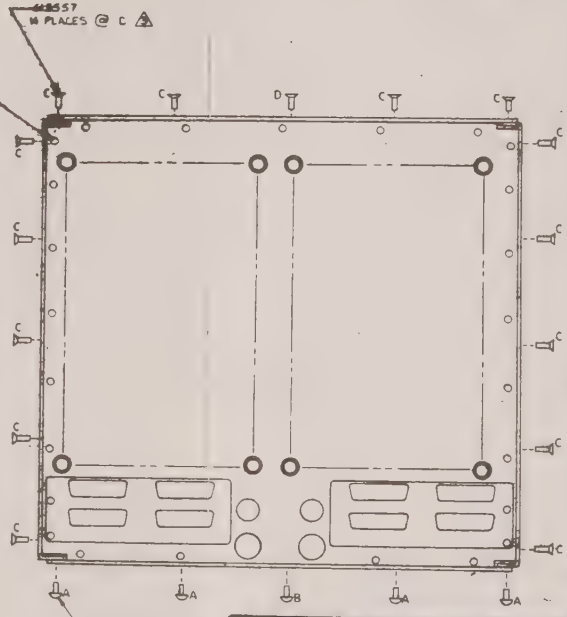
| SIZE | CODE IDENT NO | DWG NO | REV |
|---|---|---|---|
| D | 21793 | 453060 | 2/A |

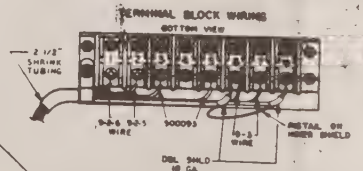
SCALE NONE SHEET 1 OF 1

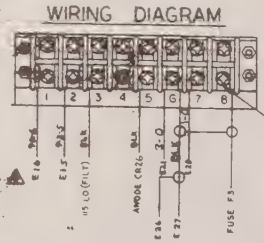
| REVISIONS | | | | |
|---|---|---|---|---|
| LTR | DESCRIPTION | DR | CHK | APPD |
| A | RELEASED PER DRN # 888 | | | |
| B | REVISED PER EO 5185 | | | |
| C | REVISED PER EO 5312 | | | |
| D | REVISED PER EO 5406 | | | |
| E | DELETE 610407 / NOTE 7. EO 5501 | | | |

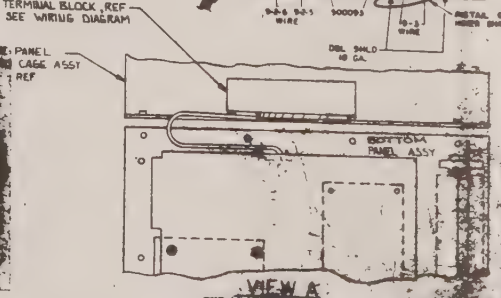





UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES AND INCLUDE THICKNESS OF PLATING

TOLERANCES

DECIMALS X.039 XX.010 XXX.005 | ANGLES OF BD FORMED 1°0 | HOLE DIAMETERS ±.004 ±.001

DIMENSIONS AND TOLERANCES PER USAS Y14.5

MATERIAL SEE L/M | FINISH

| | | |
|---|---|---|
| DRAWN | MONROY | 2 JULY 1969 |
| CHECK | | |
| DESIGN | J MONROY | 1969 |
| MECH ENGR | | |
| PROJ ENGR | | |
| QUAL ENGR | | |
| APPD | | 6-4-69 |

4032 3 | 160B

DANA DANA LABORATORIES INC. IRVINE, CALIFORNIA

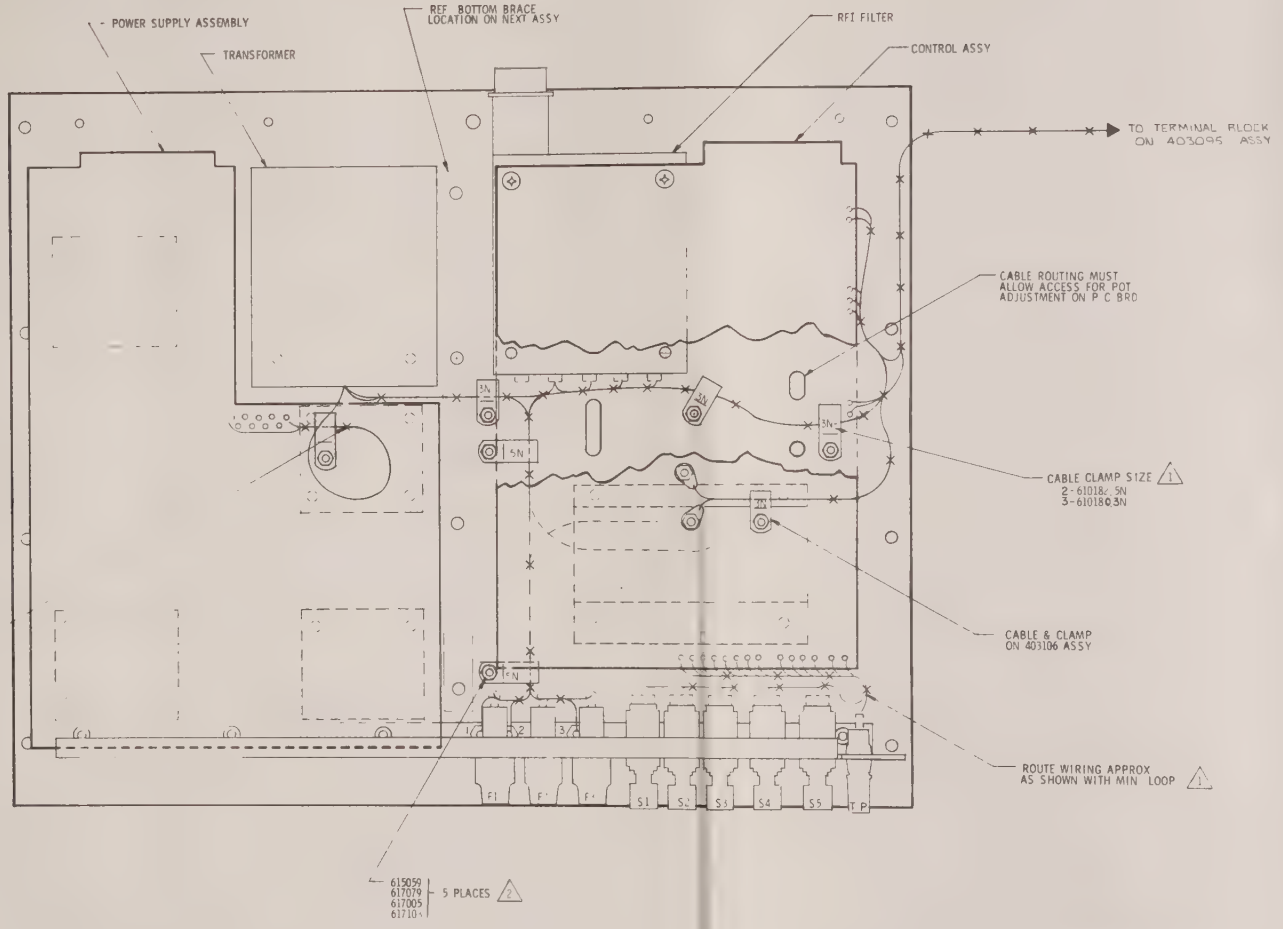
ENCLOSURE ASSEMBLY-16013

| SIZE | CODE IDENT NO | DWG NO. | REV |
|---|---|---|---|
| D | 21793 | 403235 | E |

SCALE 1/2 | SHEET 1 OF 4

SHEET 4 IS "A" SIZE

| REVISIONS | | | | |
|---|---|---|---|---|
| LTR | DESCRIPTION | DR | CHK | APPD |
| | RELEASED PER DRN # | | | |




# CABLE ROUTING DETAIL

2. APPLY LOCTITE PER APPLICATION SPEC 900075.

1. WIRE COLOR, CABLE TYPE AND TERMINATION POINTS SHOWN ON WIRING DIAGRAM, SHT 3. ROUTE WIRING AND CABLES APPROX. AS SHOWN, SPOT TIE ("X") AS REQ'D

NOTES: UNLESS OTHERWISE SPECIFIED

| NEXT DWG | USED ON | NEXT DWG | FINAL ASSY | QTY REQD |
|---|---|---|---|---|
| 403235 | 160 B | 1 | 1 | |
| 403090 | 160 A | 1 | 1 | |
| APPLICATION | | | | |

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES AND INCLUDE THICKNESS OF PLATING

TOLERANCES

| DECIMALS | ANGLES | HOLE DIAMETERS |
|---|---|---|
| X.030 | 0° 30' | + .004 |
| XX .020 | FORMED | - .001 |
| XXX .010 | 1° 0' | |

DIMENSIONS AND TOLERANCES PER USAS Y14.15

MATERIAL: SEE L/M SHT 1

FINISH:

| | | |
|---|---|---|
| DRAWN | | |
| CHECK | | |
| DESIGN | | |
| MECH ENGR | | |
| PROJ ENGR | C. M. Keyes | 5-5-69 |
| PROD ENGR | | 6-3-69 |

Norment 5/2/69

DANA LABORATORIES INC.
IRVINE CALIFORNIA

# BOTTOM PANEL ASSY-160 ENCLOSURE

| SIZE | CODE IDENT NO | DWG NO | REV |
|---|---|---|---|
| D | 21793 | 403104 | D |

SCALE 1/1 SHEET 2 OF 7

DANA

# BILL OF MATERIAL

PROJECT 160A, 160B



| C C | ASSY. NO. | REV | PART NO. | REV | LINE ITEM | U/C | DESCRIPTION | QTY | KITTING INFORMATION REQ'D QTY | KITTING INFORMATION ISSUE QTY | KITTING INFORMATION SHORT QTY | ENG. REL. DATE | COMMENTS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| C A | 403104 | | | | | | BOTTOM PANEL ASSY | | | | | | |
| C P | | | 300051 | | | | TRANSFORMER PWR. | 1 | | | | | |
| C P | | | 403105 | | | | ASSY - PWR. SUPPLY | 1 | | | | | |
| C P | | | 403106 | | | | PCB ASSY - CONTROLLER | 1 | | | | | |
| C P | | | 453089 | | | | PANEL BOTTOM | 1 | | | | | |
| C P | | | 453103 | | | | CONTROL PANEL MTG | 1 | | | | | |
| C P | | | 453115 | | | | RFI FILTER | 1 | | | | | |
| C P | | | | | | | | | | | | | |
| C P | | | 500006 | | | | CABLE - STORM B24-19/36N-52V | | | | | | A/R |
| C P | | | 500059 | | | | WIRE - 18GA - DOUBLE SHLD. | | | | | | |
| | | | 500070 | | | | WIRE - TEFLON 24 GA COLOR O-2 | | | | | | |
| | | | 500071 | | | | WIRE - TEFLON 24GA. COLOR O-3 | | | | | | |
| | | | 500093 | | | | WIRE - STRANDED 16GA TEFLON INSULA. | | | | | | |
| | | | 524911 | | | | WIRE - STR - 24GA 9-1-1 | | | | | | |
| | | | 524912 | | | | 9-1-2 | | | | | | |
| | | | 524913 | | | | 9-1-3 | | | | | | |
| | | | 524914 | | | | 9-1-4 | | | | | | |
| | | | 524915 | | | | 9-1-5 | | | | | | |
| | | | 524916 | | | | 9-1-6 | | | | | | |
| | | | 524917 | | | | 9-1-7 | | | | | | |
| | | | 524918 | | | | 9-1-8 | | | | | | |
| | | | 524919 | | | | 9-1 | | | | | | |
| | | | 524920 | | | | 9-2-0 | | | | | | |
| | | | 524[illegible] | | | | 9-2 | | | | | | |

BOTTOM PANEL ASSY.
160 ENCLOSURE

(M)

SIZE A | CODE IDENT NO. 21793 | DWG NO. 403104 | REV D | REL PER DRN NO. 887 | SHEET 5 OF 7

DANA

# BILL OF MATERIAL

PROJECT 160 A ENCL.



| C C | ASSY. NO. | REV | PART NO. | R E V | LINE ITEM | U/C | DESCRIPTION | QTY | KITTING INFORMATION REQ'D QTY | ISSUE QTY | SHORT QTY | ENG REL: DATE | COMMENTS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| C A | 403104 | | | | | | BOTTOM PANEL ASSY | | | | | | |
| C P | | | 524923 | | • | | WIRE-STR-24GA 9-2-3 | | | | | | A/R |
| C P | | | 524924 | | • | | 9-2-4 | | | | | | |
| C P | | | 524925 | | • | | 9-2-5 | | | | | | |
| C P | | | 524926 | | • | | 9-2-6 | | | | | | |
| C P | | | 600188 | | • | | INS-1451 USECO | 4 | | | | | |
| C P | | | 600330 | | • | | BINDING POST SUPERIOR #DF21BC | 1 | | | | | |
| C P | | | 600332 | | • | | BINDING POST SUPERIOR # DF 21RC | 1 | | | | | |
| C P | | | 600470 | | • | | SW-PUSH BUTTON, MOMENT | 1 | | | | | |
| C P | | | 600488 | | • | | SW-PUSH BUTTON, SPDT YELLOW | 1 | | | | | |
| | | | 600489 | | • | | SW-PUSH BUTTON, BLUE | 1 | | | | | |
| | | | 600490 | | • | | SW-PUSH BUTTON RED | 1 | | | | | |
| | | | 600491 | | • | | SW-PUSH BUTTON GRN | 1 | | | | | |
| | | | 610180 | | • | | CABLE CLAMP BURNDY HP3N | 3 | | | | | |
| | | | 610182 | | • | | CABLE CLAMP BURNDY HP5N | 2 | | | | | |
| | | | 610324 | | • | | NUT PRESS 6-32 S-632-2 PEM | 3 | | | | | |
| | | | 610347 | | • | | NUT PRESS 8-32 S-832-2 PEM | 12 | | | | | |
| | | | 615059 | | • | | SCR PPH STLS 6-32x308 | 16 | | | | | A/R |
| | | | 615062 | | • | | 6-32x 5/8 | 4 | | | | | |
| | | | 615074 | | • | | 8-32x 3/8 | 14 | | | | | |
| | | | 615079 | | • | | 8-32x 7/8 | 4 | | | | | |
| | | | 615554 | | • | | SCR PFH STLS 6-31x 1/8 | 4 | | | | | |
| | | | 617079 | | • | | WASH INT LOCK # 6 | 20 | | | | | |
| | | | 617080 | | • | | WASH INT LOCK # 8 | 12 | | | | | |

BOTTOM PANEL ASSY.
160 ENCLOSURE

SIZE A | CODE IDENT NO. 21793 | DWG NO. 403104 | REV D | SHEET 6 OF 7

REL PER DRN NO. 887

DANA

# BILL OF MATERIAL

PROJECT 160A, 160B



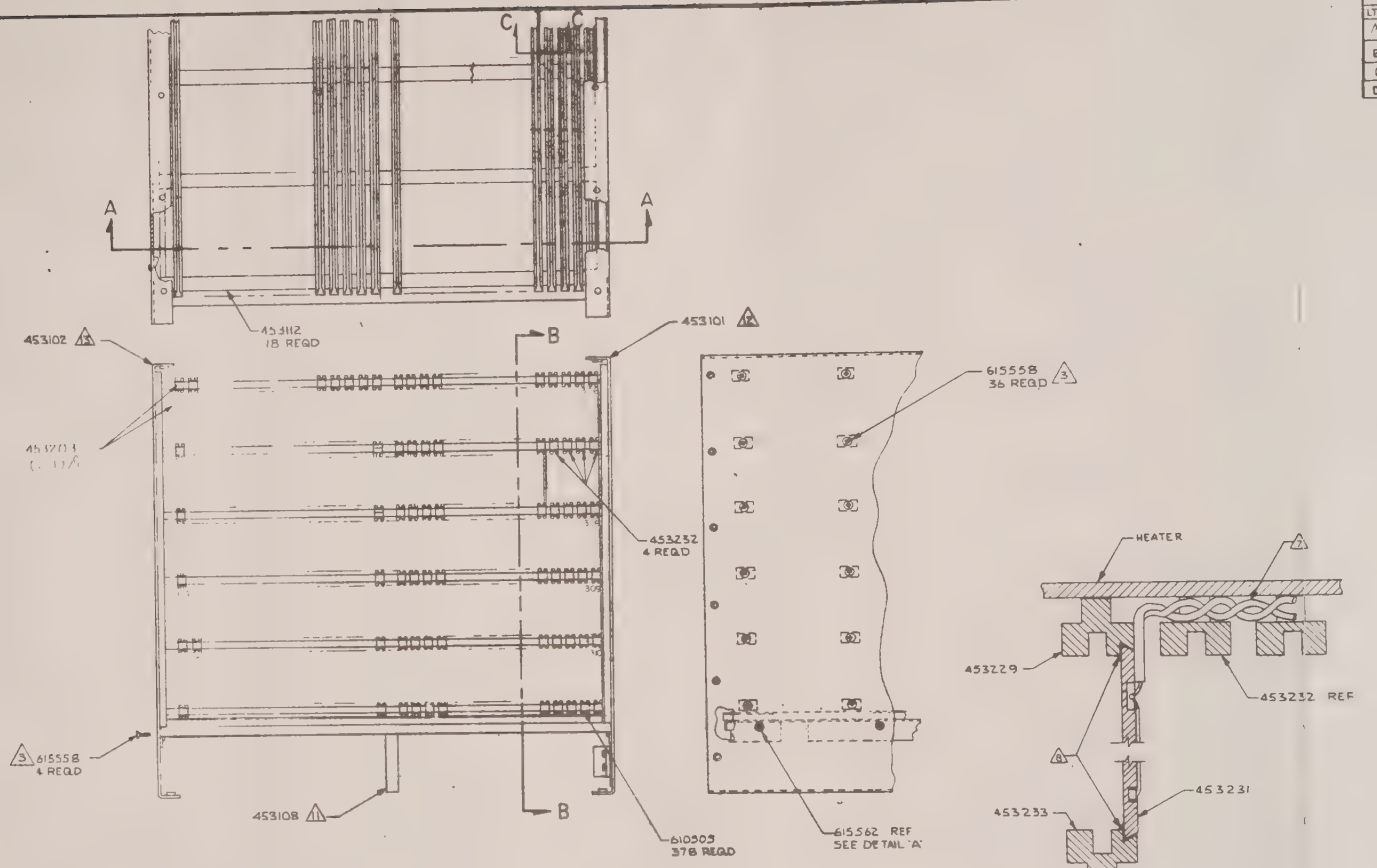
| C C | ASSY. NO. | REV | PART NO. | F E V | LINE ITEM | U/C | DESCRIPTION | QTY | KITTING INFORMATION REQ'D QTY | KITTING INFORMATION ISSUE QTY | KITTING INFORMATION SHORT QTY | ENG. REL. DATE | COMMENTS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| C A | 403104 | | | | | | BOTTOM PANEL ASSY | | | | | | |
| C P | | | 920305 | | | | FUSE HOLDER | 3 | | | | | |
| C P | | | 920328 | | | | GRADE CV LOCKTITE SEALANT | | | | | | A/R |
| C P | | | 920469 | | | | THERMAL JOINT COMPOUND | | | | | | A/R |
| C P | | | 920423 | | | | LAMP-T-1 3/4 28V INCAND | 5 | | | | | |
| C P | | | 920424 | | | | FUSE 15 AMP SLO BLO CER CORE | 1 | | | | | |
| C P | | | 920443 | | | | FUSE 8 AMP 1/4 x 1 1/4 CER (3AB) | 1 | | | | | |
| C P | | | 921539 | | | | FUSE 250V, MDL-1, FUSETRON | 1 | | | | | |
| C P | | | | | | | | | | | | | |
| C P | | | | | | | | | | | | | |

BOTTOM PANEL ASSY.
160 ENCLOSURE

SIZE A | CODE IDENT NO. 21793 | DWG NO. 403104 | REV D | SHEET 7 OF 7

REL PER DRN NO. 887

| REVISIONS | | | | |
|---|---|---|---|---|
| LTR | DESCRIPTION | DR | CHK | APPD |
| A | RELEASED PER DRN # 888 | | | |
| B | REVISED PER EO 5314 | | | |
| C | REVISED PER EO 5435 | | | |
| D | REVISED PER EO 5504 | | | |




10 REFERENCE: EACH HEATER HAS 4 WIRES; RED AND BLACK FOR 110 VAC; WHITE AND GREEN FOR 26 VDC




SECTION C-C
SCALE 4/1

4A SEE SHEET 13 OF 18
4B SEE SHEET 12 OF 18
4A SEE SHEET 14 OF 18

| | | | | |
|---|---|---|---|---|
| 403235 | 1608 | 1 | 1 | |
| NEXT DWG | USED ON | REQ PER | PER ASSY | |
| APPLICATION | | QTY REQD | | |

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES AND INCLUDE THICKNESS OF PLATING

TOLERANCES

| DECIMALS | ANGLES | HOLE DIAMETERS |
|---|---|---|
| X.030 | 0° 30' | +.004 |
| XX.020 | FORMED | -.001 |
| XXX.010 | 1° 0' | |

DIMENSIONS AND TOLERANCES PER USAS Y14.15

MATERIAL: SEE L/M
FINISH:

| | | |
|---|---|---|
| DRAWN | J. MONROY | 7/1/69 |
| CHECK | | |
| DESIGN | J. MONROY | 7/1/69 |
| MECH ENGR | Williams | 7/1/69 |
| PROJ ENGR | W. MacKenzie | 7.9 |
| PROD ENGR | E. Johnson | 7/1/69 |
| Manuf | | 7/1/69 |

DANA LABORATORIES INC.
IRVINE, CALIFORNIA

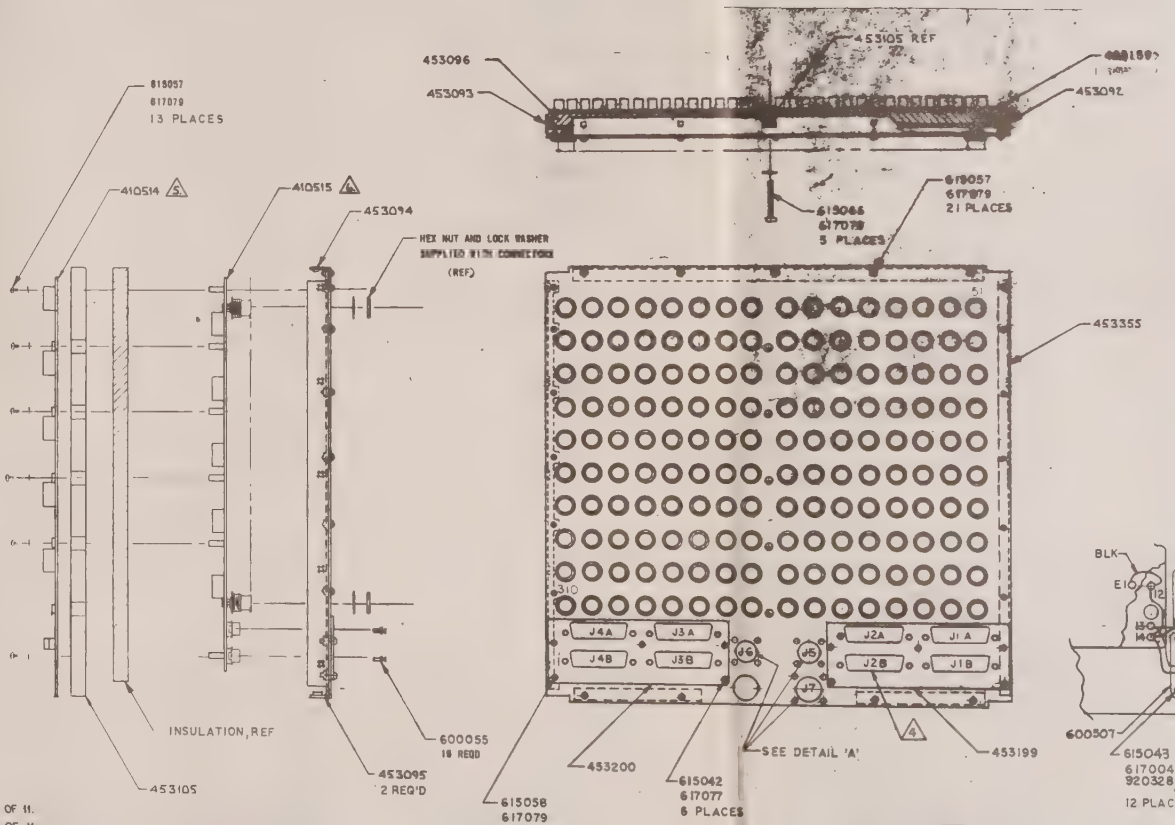
CARD CAGE ASSY
1601B

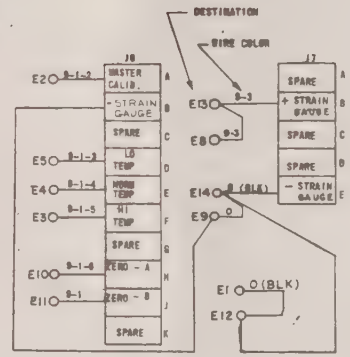
| SIZE | CODE IDENT NO | DWG NO | REV |
|---|---|---|---|
| D | 21793 | 403238 | D |

SCALE 1/2 SHEET 1 OF 18

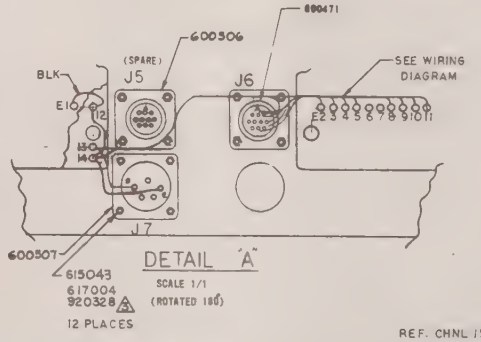
SHEET 16, 17, 18, ARE 'A' SIZE B/M

| REVISIONS | | | |
|---|---|---|---|
| LTR | DESCRIPTION | DATE | APPROVED |
| A | RELEASED PER ORR # 886 | 6-4-69 | |
| B | ADD 430853 TO B/M PER EO. 5002 | | |
| C | REVISED PER EO 5184 | | |
| D | REVISED PER EO 5313 | | |
| E | REVISED PER EO 5410 | | |




WIRING DIAGRAM




DETAIL 'A'
SCALE 1/1
(ROTATED 180°)

REF. CHNL 151-310

(1) SEE SHEET 3 OF 11.
(2) SEE SHEET 2 OF 11.
(3) MECHANICAL KEYING WAS ACHIEVED BY FILLING ONE SOCKET ON EACH OUTPUT CONNECTOR WITH SOLDER AS FOLLOWS: J1A/B-SOCKET #23, J2A/B-SOCKET #24, J3A/B-SOCKET #28, J4A/B-SOCKET #29.
(4) APPLY LOCTITE, P/N 920328 PER APPLICATION SPEC 900075.
2. CONNECTION DIAGRAM FOR COMPLETE REAR MODULE ASSY AND SUB-ASSEMBLYS SEE 430853.
1. ASSY PROCEDURES AND PROCESSES TO CONFORM TO DANA WORKMANSHIP STANDARDS.

NOTES: UNLESS OTHERWISE SPECIFIED

| | | | |
|---|---|---|---|
| #403235 | 160B | 1 | 1 |

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES AND INCLUDE THICKNESS OF PLATING
TOLERANCES: DECIMALS X.030, XX.030, XXX.010; ANGLES 0° 30' FORMED 1° 0'; HOLE DIAMETERS + .004 - .001
DIMENSIONS AND TOLERANCES PER USAS Y14.15
MATERIAL: SEE L/M
FINISH

| | | |
|---|---|---|
| DRAWN | Lee Williams | 5-28-69 |
| CHECK | | |
| DESIGN | MONROY | 27 MAY 1969 |
| STRESS ENGR | | |
| PROJ ENGR | | 6-4-69 |
| PROD ENGR | | 6-4-69 |
| QUALITY | | 6-4-69 |

DANA LABORATORIES INC.
IRVINE CALIFORNIA

REAR MODULE ASSY - 160B

| SIZE | CODE IDENT NO | DWG NO |
|---|---|---|
| D | 21793 | 403236 |

SCALE 1/2

SHEETS 9, 10 (1)

DANA

# NEW BILL OF MATERIAL INPUT

PROJECT _____

PAGE _____ OF _____

| C C | ASSY. NO. | REV | PART NO. | REV | LINE ITEM | U/C | DESCRIPTION | QTY | KITTING INFORMATION REQ'D QTY | KITTING INFORMATION ISSUE QTY | KITTING INFORMATION SHORT QTY | ENG. REL. DATE | COMMENTS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 2 | 3 8 | 9 10 | 11 16 | 17 | 18 22 | 23 24 | | 25 29 | | | | | |
| C A | 403085 | | | | | | | | | | | | |
| C P | | | 000101 | | | | RES 100 1/4W | 4 | | | | | R85, R86, R87, R88 |
| C P | | | 000102 | | | | " 1K " | 2 | | | | | R37, R47 |
| C P | | | 000103 | | | | " 10K " | 2 | | | | | R43, R50 |
| C P | | | 000104 | | | | " 100K " | 2 | | | | | R60, R81 |
| C P | | | 000106 | | | | " 10M " | 1 | | | | | R11 |
| C P | | | 000107 | | | | " 100M " | 1 | | | | | R1 |
| C P | | | 000135 | | | | " 1.3M " | 1 | | | | | R80 |
| C P | | | 000162 | | | | " 1.6K " | 1 | | | | | R82 |
| C P | | | 000185 | | | | " 1.8M " | 1 | | | | | R78 |
| | | | 000203 | | | | " 20K " | 2 | | | | | R66, R70 |
| | | | 000204 | | | | " 200K " | 2 | | | | | R53, R54 |
| | | | 000303 | | | | " 30K " | 1 | | | | | R55 |
| | | | 000334 | | | | " 330K " | 1 | | | | | R79 |
| | | | 000361 | | | | " 360 " | 2 | | | | | R8, R9 |
| | | | 000363 | | | | " 36K " | 1 | | | | | R49 |
| | | | 000470 | | | | " 47 " | 1 | | | | | R10 |
| | | | 000472 | | | | " 4.7K " | 1 | | | | | R51 |
| | | | 000473 | | | | " 47K " | 1 | | | | | R57 |
| | | | 000475 | | | | " 4.7M " | 2 | | | | | R19, R24 |
| | | | 000514 | | | | " 510K " | 2 | | | | | R65, R69 |
| | | | 000515 | | | | " 5.1M " | 2 | | | | | R18, R23 |
| | | | 000622 | | | | " 6.2K " | 1 | | | | | R61 |
| | | | 000624 | | | | " 620K " | 2 | | | | | R58, R59 |

P.C.B. ASSY— AMPLIFIER, 2550

SIZE A | CODE IDENT NO. 21793 | DWG NO. 403085 | REV J

REL PER DRN NO. 8871 | SHEET 2 OF 6

DRM 7390

DANA

# NEW BILL OF MATERIAL INPUT

PROJECT _____

PAGE _____ OF _____

| C C | ASSY. NO. | REV | PART NO. | REV | LINE ITEM | U/C | DESCRIPTION | QTY | KITTING INFORMATION REQ'D QTY | ISSUE QTY | SHORT QTY | ENG. REL. DATE | COMMENTS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| C A | 403085 | | | | | | | | | | | | |
| C P | | | 000910 | | | | RES 91 1/4W | 1 | | | | | R84 |
| C P | | | 000243 | | | | " 24K " | 1 | | | | | R83 |
| C P | | | 010059 | | | | " RN60D 20K 1% | 1 | | | | | R35 |
| C P | | | 010060 | | | | " " 10K 1% | 3 | | | | | R21, R34, R36 |
| C P | | | 010363 | | | | " " 4.32K 1% | 1 | | | | | R52 |
| C P | | | 010364 | | | | " " 43.2K 1% | 1 | | | | | R56 |
| C P | | | 010365 | | | | " " 46.4K 1% | 1 | | | | | R48 |
| C P | | | 010366 | | | | " " 36.5K 1% | 1 | | | | | R77 |
| C P | | | 010367 | | | | " " 402K 1% | 1 | | | | | R72 |
| | | | 010373 | | | | " PME60, T-2, 1M. 1% | 2 | | | | | R12, R13 |
| | | | 010375 | | | | " RN60D 40.2K 1% | 1 | | | | | R68 |
| | | | 010376 | | | | " " 60.4K 1% | 1 | | | | | R64 |
| | | | 010377 | | | | " " 34K 1% | 1 | | | | | R71 |
| | | | 010378 | | | | 53.6K | 1 | | | | | R67 |
| | | | 020415 | | | | " J9 100K .1% | 4 | | | | | R32, R33, R62, R63, |
| | | | 020514 | | | | " " 1.087K .05% | 1 | | | | | R29 |
| | | | 020515 | | | | " " 520.8 .05% | 1 | | | | | R30 |
| | | | 020516 | | | | " " 203.3 .05% | 1 | | | | | R31 |
| | | | 020517 | | | | " " 8.333K .05% | 1 | | | | | R27 |
| | | | 020518 | | | | " " 2.381K .05% | 1 | | | | | R28 |
| | | | 020519 | | | | " " 49.97K .05% | 1 | | | | | R6 |
| | | | 020520 | | | | " " 24.97K .05% | 1 | | | | | R7 |
| | | | 020521 | | | | " " 7.675K .1% | 2 | | | | | R44, R46 |

P.C.B. ASSY - AMPLIFIER 2550 (W)

SIZE A | CODE IDENT NO. 21793 | DWG NO. 403085 | REV J

REL PER DRN NO. 827 | SHEET 3 OF 6

DANA

# NEW BILL OF MATERIAL INPUT

PROJECT _____

PAGE _____ OF _____

| C C 1 2 | ASSY. NO. 3 8 | REV 9 10 | PART NO. 11 16 | REV 17 | LINE ITEM 18 22 | U/C 23 24 | DESCRIPTION | QTY 25 29 | KITTING INFORMATION REQ'D QTY | KITTING INFORMATION ISSUE QTY | KITTING INFORMATION SHORT QTY | ENG. REL. DATE | COMMENTS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| C A | 403085 | | | | | | | | | | | | |
| C P | | | 020522 | | | | RES, J9, 199K .1% | 1 | | | | | R74 |
| C P | | | 020523 | | | | " " 10.5K .1% | 2 | | | | | R15, R17 |
| C P | | | 020524 | | | | " " 250K .05% | 1 | | | | | R4 |
| C P | | | 020525 | | | | " " 100K .05% | 1 | | | | | R5 |
| C P | | | 040137 | | | | POT 50K 5% | 2 | | | | | R73, R76 |
| C P | | | 040138 | | | | " 50 5% | 1 | | | | | R45 |
| C P | | | 040139 | | | | " 500 5% | 1 | | | | | R38 |
| C P | | | 040140 | | | | " 10K 5% | 2 | | | | | R20, R22 |
| C P | | | | | | | | | | | | | |
| | | | 100017 | | | | CAP DISC .01 UF | 4 | | | | | C27, 28, 29, 30 |
| | | | 100006 | | | | CAP DISC 10 pF | 4 | | | | | C12, C13, C26, C31 |
| | | | 100013 | | | | " " 15 pF | 1 | | | | | C10 |
| | | | 100028 | | | | " " .002 UF | 3 | | | | | C22, C23, C25, |
| | | | 100025 | | | | " " .005 UF | 1 | | | | | C24 |
| | | | 101145 | | | | " " 100 pF | 3 | | | | | C8, C15, C18 |
| | | | 101642 | | | | " " 150 pF | 1 | | | | | C21 |
| | | | 120200 | | | | " FILM .001 UF | 3 | | | | | C3 C4 C5 |
| | | | 120201 | | | | " " .01 UF | 5 | | | | | 1, 2, 6, 7, 9, |
| | | | 403415 | | | | FSV ASSY FILTER CAP | 1 | | | | | |
| | | | | | | | | | | | | | |
| | | | | | | | | | | | | | |
| | | | | | | | | | | | | | |
| | | | 130004 | | | | " CER TRIM 2-8 pF | 1 | | | | | C11 |

P.C.B. ASSY— AMPLIFIER 2550

SIZE A | CODE IDENT NO. 21793 | DWG NO. 403085 | REV J

REL PER DRN NO. 857 | SHEET 4 OF 6

DANA

# NEW BILL OF MATERIAL INPUT

PROJECT _____

PAGE _____ OF _____

| C C 1 2 | ASSY. NO. 3–8 | REV 9 10 | PART NO. 11–16 | REV 17 | LINE ITEM 18–22 | U/C 23 24 | DESCRIPTION | QTY 25–29 | KITTING INFORMATION REQ'D QTY | KITTING INFORMATION ISSUE QTY | KITTING INFORMATION SHORT QTY | ENG. REL. DATE | COMMENTS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| C A | 403085 | | | | | | | | | | | | |
| C P | | | 200043 | | | | TRANS 2N3565 | 13 | | | | Q | 2,3,13,14,15,16,17, |
| C P | | | | | | | | | | | | | 18.20,21,23,24.26 |
| C P | | | 200044 | | | | (MATCHED PAIR) 2N3565 | 1 | | | | | Q9 10 |
| C P | | | 200062 | | | | TRANS 2N4250 | 9 | | | | | 4,5,6,7,8,19,22,25,30 |
| C P | | | 200108 | | | | " 2N4860 | 1 | | | | | Q1 |
| C P | | | 200120 | | | | " SELECTED 2N3565 | 1 | | | | | Q31 |
| C P | | | 200121 | | | | " MATCHED PR. 2N3565 | 1 | | | | | Q27-28 |
| C P | | | 200172 | | | | " SELECTED 2N3565 | 1 | | | | | Q29 |
| C P | | | 201285 | | | | " DUAL [illegible] | 1 | | | | | Q12 |
| C P | | | 201462 | | | | " 1ST STAGE | 1 | | | | | Q11 |
| | | | 211083 | | | | DIODE 018 | 11 | | | | | 1,2,3,4,5,6,7,8,9, |
| | | | | | | | | | | | | | 12,13 |
| | | | 211236 | | | | " 007 | 2 | | | | | CR10, CR11 |
| | | | | | | | | | | | | | |
| | | | | | | | | | | | | | |
| | | | 403167 | | | | FSV ASSY | 1 | | | | | R1,R25,R14,R16, |
| | | | | | | | | | | | | | R26,R39,R75,R83 |
| | | | | | | | | | | | | | R40 |
| | | | | | | | | | | | | | |
| | | | | | | | | | | | | | |
| | | | | | | | | | | | | | |
| | | | 410509 | | | | P.C.B. AMP 2550 | 1 | | | | | |
| | | | 430849 | | | | SCHEMATIC | | | | | | R.L.F |

P.C.B. ASSY – AMPLIFIER 2550

REV J

SIZE A | CODE IDENT NO. 21793 | DWG NO. 4030850 | SHEET 5 OF 6

REL PER DRN NO. 897

DANA

# NEW BILL OF MATERIAL INPUT

PROJECT _____

PAGE _____ OF _____

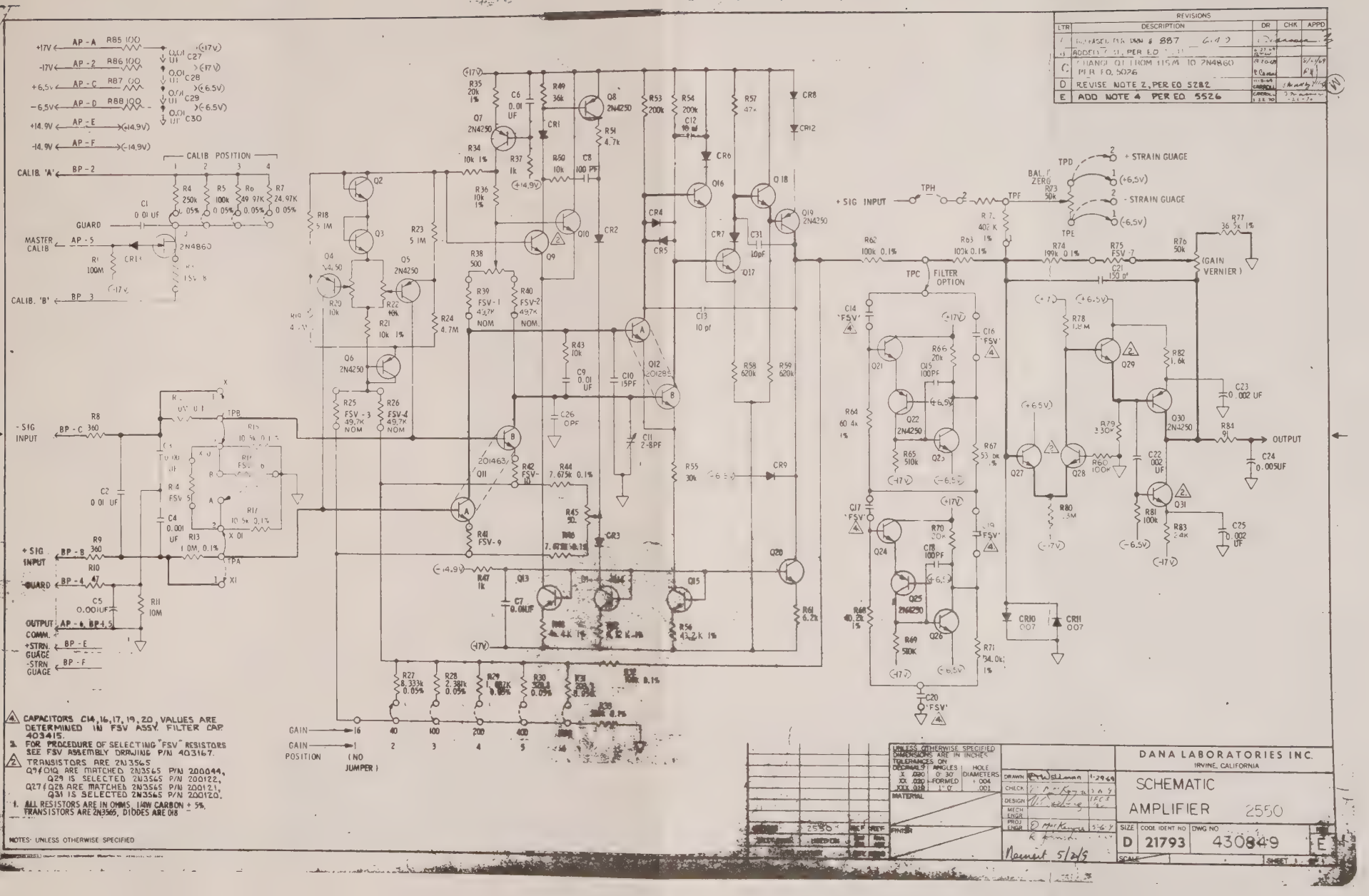
| C C | ASSY. NO. | REV | PART NO. | REV | LINE ITEM | U/C | DESCRIPTION | QTY | KITTING INFORMATION REQ'D QTY | KITTING INFORMATION ISSUE QTY | KITTING INFORMATION SHORT QTY | ENG. REL. DATE | COMMENTS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| C A | 403085 | | | | | | | | | | | | |
| C P | | | 453131 | | | | CUP TRANS. MTG. | 2 | | | | | |
| C P | | | 453136 | | | | TRANS COVER | 2 | | | | | |
| C P | | | | | | | | | | | | | |
| C P | | | 600245 | | | | JUMPER | 6 | | | | | TP-D, TP-E, R3, |
| C P | | | | | | | | | | | | | R41, R42, R75 |
| C P | | | 600297 | | | | FSV JACK | 15 | | | | | |
| C P | | | 610234 | | | | FORKED STANDOFF | 49 | | | | | |
| C P | | | 610552 | | | | SPRING PIN | 1 | | | | | |
| C P | | | 453349 | | | | EXTRACTOR HANDLE | 1 | | | | | |
| | | | | | | | | | | | | | |
| | | | 920007 | | | | TRANSIPAD | 1 | | | | | |

P.C.B. ASSY- AMPLIFIER 2550

REV J

SIZE A | CODE IDENT NO. 21793 | DWG NO. 403085 | SHEET 6 OF 6

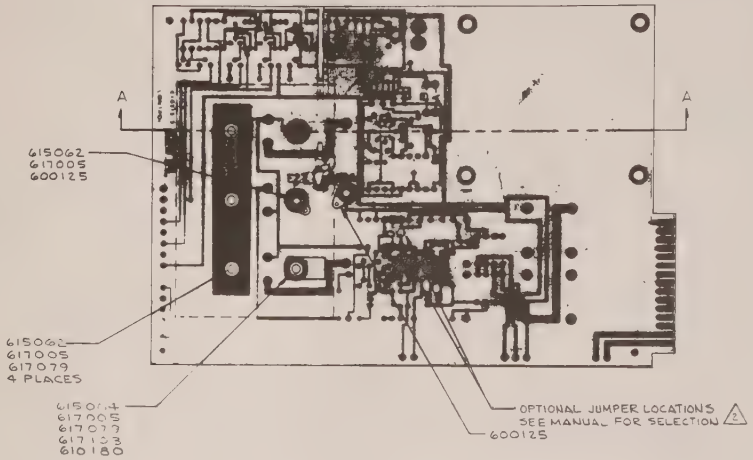
REL PER DRN NO. [illegible]

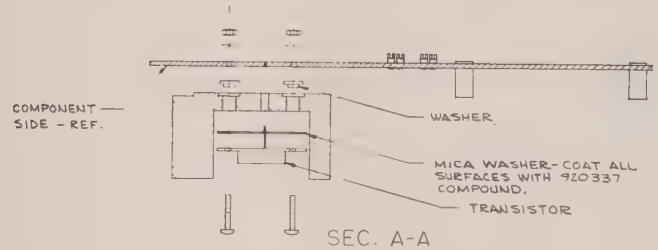



1. CAPACITORS C14, 16, 17, 19, 20, VALUES ARE DETERMINED IN FSV ASSY. FILTER CAP 403415.
3. FOR PROCEDURE OF SELECTING "FSV" RESISTORS SEE FSV ASSEMBLY DRAWING P/N 403167.
2. TRANSISTORS ARE 2N3565
   Q9 & Q10 ARE MATCHED 2N3565 P/N 200044,
   Q29 IS SELECTED 2N3565 P/N 200122,
   Q27 & Q28 ARE MATCHED 2N3565 P/N 200121,
   Q31 IS SELECTED 2N3565 P/N 200120.
4. ALL RESISTORS ARE IN OHMS 1/4W CARBON ± 5%. TRANSISTORS ARE 2N3565, DIODES ARE D18

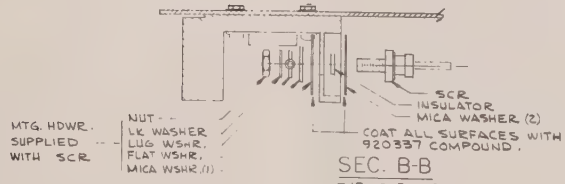
NOTES: UNLESS OTHERWISE SPECIFIED

| REVISIONS | | | | |
|---|---|---|---|---|
| LTR | DESCRIPTION | DR | CHK | APPD |
| | RELEASED PER DRN # SEE SHT 1 | | | |




SEC. A-A
TYP 3 PLACES




SEC. B-B
TYP. 2 PLACES

| REF DES OR ITEM | P N | DESCRIPTION | QTY |
|---|---|---|---|
| R1 | 001758 | 330Ω ± 5% 1W | 2 |
| R2 | 001758 | 330Ω ± 5% 1W | REF |
| R3 | 020114 | 917.4Ω ± 5% | 2 |
| R4 | 020114 | 917.4Ω ± 5% | REF |
| R5 | 000512 | 5.1K 1/4 W | 1 |
| R6 | 040109 | 5K POT | 1 |
| R7 | 020482 | 7.5K ±.05% | 1 |
| R8 | 020352 | 3.6K ± .05% | 1 |
| R9 | 040091 | 1K POT | 1 |
| R10 | 020543 | 5.1K ± .1% | 1 |
| R12 | 000101 | 100Ω | 1 |
| R13 | 000101 | 100Ω | REF |
| R14 | 000152 | 1.5K | 2 |
| R15 | 010088 | 8.45K ± 1% | 1 |
| R16 | 040093 | 500Ω POT | 1 |
| R17 | 020146 | 333.3Ω ± .1% | 1 |
| R18 | 000273 | 27K | 2 |
| R19 | 001757 | 1.5K 1W ± 5% | 1 |
| R20 | 000561 | 560Ω | 1 |
| R21 | 020532 | 0.1Ω 5W .1% | 1 |
| R22 | 020532 | 0.1Ω 5W 1% | REF |
| R23 | 000101 | 100Ω | REF |
| R24 | 000101 | 100Ω | REF |
| R25 | 000152 | 1.5K | REF |
| R26 | 010022 | 46.4K ± 1% | 1 |
| R27 | 010212 | 4.64K ± 1% | 1 |
| R28 | 040092 | 20K POT | 3 |
| R29 | 000201 | 200Ω | 1 |
| R30 | 000103 | 10K 1/4W | 3 |
| R31 | 000562 | 5.6K | 1 |
| R32 | 010018 | 1.4 K ± 1% | 1 |
| R33 | 040092 | 20K POT | REF |
| R34 | 010020 | 4.99K ± 1% | 1 |
| R35 | 040157 | 10K POT | 1 |
| R36 | 040092 | 20K POT | REF |
| R37 | 010039 | 9.09K ± 1% | 1 |
| R38 | 000103 | 10K 1/4W | REF |
| R39 | 000273 | 27K | REF |
| R40 | 000912 | 9.1K | 1 |
| R41 | 000682 | 6.8K | 1 |
| R42 | 000103 | 10K 1/4W | REF |
| R43 | 001675 | 100Ω 1/2W | 1 |
| R44 | 000102 | 1K | 2 |
| R45 | 000102 | 1K | REF |
| 3 | | | |

| REF DES OR ITEM | P N | DESCRIPTION | QTY |
|---|---|---|---|
| C1 | 110061 | 100UF/50V | 2 |
| C2 | 110061 | 100UF/50V | REF |
| C4 | 100017 | .01UF DISC | 2 |
| C5 | 100025 | .005UF DISC | 2 |
| C6 | 101175 | 220UF DISC | 2 |
| C7 | 100017 | .01UF DISC | REF |
| C8 | 100025 | .005UF DISC | REF |
| C9 | 101175 | 220UF DISC | REF |
| CR1 | 210004 | SD4 | 8 |
| CR2 | 210004 | SD4 | REF |
| CR3 | 210004 | SD4 | REF |
| CR4 | 210004 | SD4 | REF |
| CR5 | 220022 | IN965B | 2 |
| CR6 | 220022 | IN965B | REF |
| CR7 | 220017 | SZ30483 | 2 |
| CR8 | 220017 | SZ30483 | REF |
| CR11 | 211083 | 018 | 10 |
| CR12 | 211083 | 018 | REF |
| CR13 | 220030 | 1/4M2.4AZ5 | 1 |
| CR14 | 211083 | 018 | REF |
| CR15 | | | |
| CR16 | | | |
| CR17 | | | |
| CR18 | | | |
| CR19 | | | |
| CR20 | | | |
| CR21 | 211083 | 018 | REF |
| CR22 | 210004 | SD4 | REF |
| CR23 | 200102 | 2N685 (SCR) | 2 |
| CR24 | 210004 | SD4 | REF |
| CR25 | 210004 | SD4 | REF |
| CR26 | 200102 | 2N685 (SCR) | REF |
| CR27 | 210004 | SD4 | REF |
| M1 | 230047 | MC1709, I C | 2 |
| M2 | 230047 | MC1709, I C | REF |
| Q3 | 200035 | Q14 | 2 |
| Q4 | 200092 | 2N3055 | 3 |
| Q5 | 200092 | 2N3055 | REF |

| REF DES OR ITEM | P N | DESCRIPTION | QTY |
|---|---|---|---|
| Q6 | 200092 | 2N3055 | REF |
| Q7 | 200043 | 2N3565 | 7 |
| Q8 | 200011 | 009 | 3 |
| Q9 | 200043 | 2N3565 | REF |
| Q10 | Z00044 | 2N4250 | 1 |
| Q11 | 200043 | 2N3565 | REF |
| Q12 | 200011 | 009 | REF |
| Q13 | 200043 | 2N3565 | REF |
| Q14 | 200043 | 2N3565 | REF |
| Q15 | 200043 | 2N3565 | REF |
| Q16 | 200035 | Q14 | 1 |
| Q17 | 200043 | 2N3565 | REF |
| Q18 | 200011 | 009 | REF |

| REF DES OR ITEM | P/N | DESCRIPTION | QTY |
|---|---|---|---|
| | 310053 | RELAY BR5 2KC3-26V | 1 |
| | 410513 | PCB-CONTROL | 1 |
| | 430851 | SCHEM-CONTROL | REF |
| | 452723 | SPACER | 6 |
| | 452725 | COMP. CLIP | 2 |
| | 453201 | HEATSINK | 1 |
| | 500058 | WIRE-24GA BLK | A/R |
| | 500059 | CABLE | A/R |
| | 500093 | WIRE-16GA BLK | A/R |
| | 501357 | SHRINK TUBING | A/R |
| | 600125 | SOLDER LUG #6 | 2 |
| | 600137 | TERMINAL | 2 |
| | 600542 | TERMINAL | 25 |
| | 600476 | TERMINAL-TURRET | 1 |
| | 610138 | RIVET | 4 |
| | 610180 | CLAMP-3N | 1 |
| | 610234 | TERMINAL-FORKED | 8 |
| | 610539 | STD-OFF 1/2 x 5/16 DIA | 4 |
| | 615062 | SCR. 6-32 x 5/8 | 5 |
| | 615064 | SCR. 6-32 x 7/8 | 1 |
| | 617005 | HEXNUT-6-32 | 6 |
| | 617079 | LK WASH. #6 | 5 |
| | 617103 | FLAT WASHER #6 | 5 |
| | 920006 | TRANSIPAD | 5 |
| | 920010 | SOLDER, BAR | A/R |
| | 920026 | SOLDER WIRE | A/R |
| | 920035 | TRANSIPAD-DUAL | 2 |
| | 920337 | SILICONE COMP | A/R |

△ ALL NOTES ON SHT. 2

NOTES. UNLESS OTHERWISE SPECIFIED

| | | | |
|---|---|---|---|
| 403104 | 160 | 1 | 1 |
| NEXT DWG | USED ON | NEXT ASSY | FINAL ASSY |
| APPLICATION | | QTY REQD | |

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES AND INCLUDE THICKNESS OF PLATING

TOLERANCES

| DECIMALS | ANGLES | HOLE DIAMETERS |
|---|---|---|
| X .030 | 0 30' | - .004 |
| XX .020 | FORMED | .001 |
| XXX .010 | 1 0' | |

DIMENSIONS AND TOLERANCES PER USAS Y14.15

MATERIAL: SEE L/M

FINISH:

| | | |
|---|---|---|
| DRAWN | [illegible] | [illegible] |
| CHECK | [illegible] | [illegible] |
| DESIGN | [illegible] | [illegible] |
| MECH ENGR | | |
| PROJ ENGR | D. Mac Kay | 5-6-9 |
| PROC (MQ) | [illegible] | [illegible] |

Recent 5/6/9

DANA DANA LABORATORIES INC.
IRVINE, CALIFORNIA

# P.C. BOARD ASSEMBLY- CONTROL, 160

| SIZE | CODE IDENT NO. | DWG NO. | REV |
|---|---|---|---|
| D | 21793 | 403106 | F |

SCALE 1/1 SHEET 3 OF 3

# Warranty

It is the practice of Dana Laboratories, Incorporated, to manufacture only products of a quality that will merit customer satisfaction. The company recognizes that customer satisfaction is achieved, not only by delivering products meeting advertised performance specifications and having a high level of reliability, but also by honestly and efficiently fulfilling their warranty obligations as set forth below.

Dana Laboratories, Inc., agrees to correct, either by repair or replacement, any defect of material or workmanship in Dana-manufactured units or components which develop within one year after delivery of the equipment to the original purchaser — provided that the equipment has been subjected only to normal and proper use.

In the event of failure of any component delivered with Dana equipment, but not manufactured by Dana Laboratories, assistance will be given the customer in obtaining, from the original manufacturer, reasonable adjustment under that manufacturer's warranty.

Any item claimed to be defective during the warranty period must be returned to Dana Laboratories, Inc., with transportation charges prepaid. The item will be repaired and returned to the purchaser with return transportation prepaid by Dana unless, of course, the item is found not to be defective or found to be damaged by misuse — in which case it will be returned to the purchaser with repair and transportation billed collect.

DANA

DANA™

MP MASTER
MA31091